ELECTRICAL ENGINEERING

SEPTEMBER
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The Cover: A new and improved telephone set is now being introduced by the Bell Telephone system. In addition to its more attractive outer appearance, the new set has improved technical characteristics which make it easier to use and provide more natural conversation with less effort. (See story on pages 770–75.)
Bell Telephone Laboratories photo

TECHNICAL-PAPER DIGESTS

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HIGHLIGHTS........

Section Growth Award Plan. Do small sections have a better chance for growth than the large ones? How does the age of a section affect its growth? These, and other pertinent points, are brought out in an article by C. G. Veinott, who was Chairman of a special committee to study a growth plan for sections (*page 757*), and in a more detailed report in the Institute Activities section (pages *820–22*).

Engineering—Its Future. The greatest problem of the engineering profession today is to make the public understand the need for superior engineering and engineers. The EJC and ECPD programs regarding manpower, the situation with respect to the draft and reserve officers, and other aspects of this important issue are described by A. C. Monteith (*pages 758–61*).

Report on Atomic Energy. How to give the electrical utilities a more active role in the atomic energy enterprise is the subject of this report by an Ad Hoc Advisory Committee to the Atomic Energy Commission. The community of interest between the AEC and the electric power industry is discussed and plans for increased co-operation are presented (*pages 763–68*).

An Improved Telephone Set. Approximately 25 million telephone sets which were introduced in 1937 are now in use. An improved model has been announced which has many new operating and physical characteristics (*pages 770–75*).

Piezoelectric Crystals as Sensing Elements. Electronic methods for detecting meteorological conditions by means of crystals are described in this article. These sensing elements have many desirable characteristics, particularly for telemetering applications (*pages 776–80*).

Electrostatic Sources of Ionizing Energy. Electrostatic methods for producing sources of high-energy particles and some of their applications in science and industry are discussed. The author describes a 2,000,000-volt unit now in use as well as a new 12,000,000-volt design now under construction at MIT (*pages 781–87*).

Telemetering Systems and Channels. Selecting the right telemetering system for the right job is essential for effective power system co-ordination. How the various requirements of a large Canadian system were met is described (*pages 796–801*).

Hermetically Sealed Components. The case for hermetically sealed components is presented this month. By protecting components in this manner from weather and human tampering the life of the equipment is greatly increased (*pages 804–07*).

Measurement of D-C Machine Parameters. The use of d-c machines in servomechanism circuits creates a need for an equivalent circuit that accounts for inductive effects in the machine. Such a circuit, and methods for finding its parameters, is suggested (*pages 787–92*).

Induction Generators for Power Generation. As a supporting unit for large power systems, the squirrel-cage induction generator offers possibilities for economical generation of extra power. Savings are brought about by lower first costs and by less maintenance expense, and the machine's simplicity of control is a distinct advantage (*pages 793–95*).

Transcontinental Radio Relay System. Like tracks left by Seven League Boots, repeater stations of the Bell System's new microwave relay system dot the countryside from Boston to San Francisco. Operating in the 4,000-megacycle range, the system provides six broad-band channels in each direction, and each channel can carry hundreds of telephone circuits or one television circuit (*pages 810–15*).

Tachometer for Angular Speed Variations. This recording instrument measures instantaneous speed variations of rotating shafts. Its sensitivity is adjustable from 0.2 to 100 per cent speed variation for full-scale deflection and it operates in a peripheral speed range from 5 to 120 feet per minute. The speed sensing unit is a photoelectric frequency generator which produces a frequency proportional to its friction drive wheel (*pages 816–19*).

Officers and Committees List: Officers and personnel of the general and technical committees for 1951–52 appear on pages 828–36. **Constitutional Amendments.** The former texts of the Constitution and amended texts are on pages 837–40.

News Index

New Membership Requirements

As announced at the Annual Meeting in Toronto on June 25, the proposed amendments to the Constitution have been approved by ballot of the membership and, in accordance with Section 69 of the Constitution, the new provisions went into effect 30 days after the Annual Meeting—or July 25, 1951.

Any applications for membership or change of grade made after July 25 must be made on new forms. It is necessary therefore that the forms previously in use be discarded and new ones obtained from AIEE headquarters or Section Membership or Transfer Committees. Any applications received on the now obsolete forms will be returned to the applicant along with information regarding the new requirements and a new form.

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8*; *Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Nov '50, p 44A	Middle Eastern District Fall General
Mar '51, p 35A	Winter General
Jul '51, p 23A	Southern District North Eastern District Great Lakes District Summer General

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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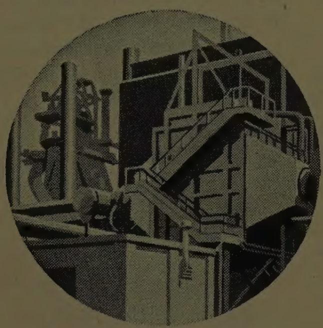

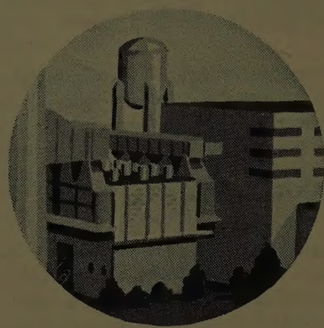

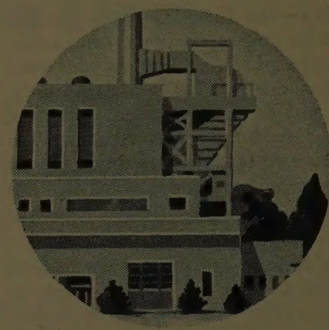

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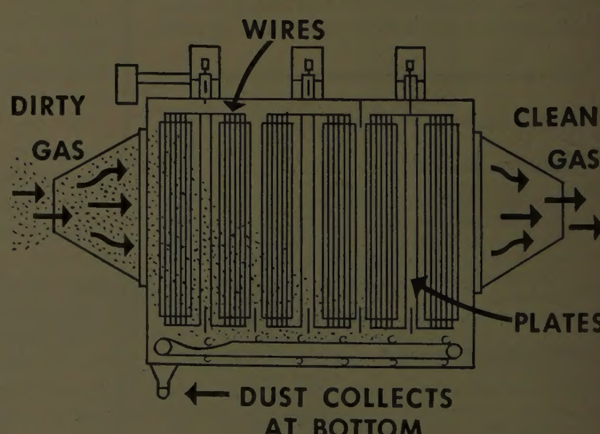

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Section Growth Award Plan

C. G. VEINOTT
PAST VICE-PRESIDENT

LAST YEAR Past-President LeClair appointed a special committee to study a plan for recognition of section growth.* A plan was developed and it vas adopted by the Board of Directors on January 25, 951; awards were made at the Summer General Meeting n Toronto (*EE, Aug '51, pp 713–14*). The primary purpose f this plan was to encourage sections to put forth greater ffort to meet the needs of their members. Details of he plan are given in the tory in *Institute Activities* entitled "Report on Plan for Recognition of Section Growth Presented" on pages 20–22. The growth formula s given in Appendix I, and ules governing the Section Growth Award are given in Appendix II. The three ables which appear in conjunction with the story show he growth factors of the large sections, of the small ections, and of the districts. As a result of the statistical vork incident to the administration of this plan, some nteresting facts came to light, from which it is possible o draw certain conclusions.

The most important fact that this special committee discovered was that local sections must put on better local programs to attract a greater attendance.

First, the membership of the Institute as a whole is growing nearly three times as fast as the attendance at ection meetings. There was a 13-per cent growth in nembership as a whole, but only a 4.5-per cent increase in ttendance at section meetings. Every one of the ten listricts had an actual increase in membership, but four f the ten actually showed a decrease of attendance at the neetings of their sections. Out of 74 sections, only two uffered a loss in membership, but 35 suffered a loss in ttendance at their meetings. Curiously enough, this lifficulty was not peculiar either to large or to small ections. Forty-seven per cent of the large sections lost in ttendance, and 47 per cent of the small sections did likewise.

What conclusions can we draw from these facts? One bvious conclusion is that the sections need to put on etter local programs in order to stimulate better attendance t local meetings. Individual members join the national ody of the Institute, and are then assigned to sections. Now, if there is a bigger percentage increase in membership han there is in attendance at local section meetings, a fair onclusion might well be drawn that the Institute as a vhole is what attracted the new member, rather than the ctivities or program of the local section where he resided. n any case, it is obvious that a large majority of the local ections need to put forth more effort to serve the interests of their members. One way to do this would be by means of better programs. Experience seems to show that it is the excellence of the program that is the principal attraction in getting out attendance. Large sections have had remarkable success in increasing local attendance by breaking down into smaller groups, such as technical discussion groups, or, where geographical limitations become a factor, into subsections. When a 15 to 17 per cent increase in total membership of a section is accompanied by a reduction of 60 to 90 per cent in attendance at local meetings, it is obvious that a better local program is needed.

Do small sections have a better chance for this growth award than the large ones? It was thought, when this formula was adopted, that the larger and particularly the older sections would not have a chance in competition against the younger sections, which would be expected to grow faster. Because of this feeling, the sections were divided into two groups according to size. However, if all of the sections had been placed in one group, the first place in the growth competition would still have gone to a large section, but the next 13 places would all have gone to small sections. Curiously enough, though, the average growth factor for all the large sections is 21.60, and for all the small sections is 20.80. Hence, it seems fair to conclude that, in general, our large sections are growing as fast as our small sections. However, dividing them into two groups by size is probably desirable.

How does the age of a section affect its growth? It was thought that only young sections would have a chance to win. For this reason all sections less than four years old were declared ineligible in the competition. But we found the ages of the four top-ranking large sections to be, respectively, 29, 22, 43, and 46 years. Likewise, the ages of the four top-ranking small sections are, respectively, 32, 21, 25, and 20. Hence, the top four in both groups were at least 20 or more years old. Growth is not confined to the young sections. Does section life begin at 20?

This plan represents the first serious attempt to recognize and award prizes to sections for their performances. The statistics give the officers and members of each and every section a chance to compare their own section with 73 other sections, or with just the sections in their own district. Moreover, they show that, in this competition, the race is not necessarily to the young, nor to the small, nor to the large. But, perhaps most important of all, the statistics show that there is a great need for the local sections to present better local programs which will attract better attendance.

. G. Veinott is with Westinghouse Electric Corporation, Lima, Ohio.

Members of the Special Committee to Study Growth Plan were: C. G. Veinott, *hairman;* D. I. Anzini; and C. C. Clos.

Engineering—Its Future

A. C. MONTEITH
FELLOW AIEE

The first five years in the engineer's professional life are the most important ones. The responsibilities of the societies and the individual, community integration, orientation and training, and continued education, are discussed.

LET'S TALK about the subject of greatest interest to people—and that is, people. Andrew Carnegie once stated that you could take away his factories and his money, but if you left him his men he could again rise to a position of leadership. Well-trained men are becoming more important than ever in our industrial life, the complexity of which has increased manyfold over Andrew Carnegie's days. A past issue of *Life* discussed the accelerating rate of scientific progress. The startling statement was made that more progress was made in the first 50 years of the 20th Century than in the previous 5,000 years. The article showed the increase in the use of power, the increase in the use of communications, and also the improvement in the destructive power that man has evolved out of the long step from the use of black powder shells in 1900 to the atom bomb in 1945.

These great strides in technological development have been made possible through the incentive system—the incentive for men to create things that will improve the American way of life. They can be traced fundamentally to engineering, on top of which has been placed the greatest productive capacity in the world.

ENGINEERING ACCOMPLISHMENTS

A GOOD MEASURE OF the increase in productive capacity of this country is the use of electric energy. Electric energy is the servant that increases the production of a pair of hands. In 1900, we had 2.5 horsepower per worker while in 1950 we had 7.5 horsepower per worker. If we consider that 1 horsepower does the work of 50 men, we see that there is now the equivalent of 375 men back of each worker in 1951, or, to put it another way, the average worker has 375 slaves working for him in the form of energy—a measure of our standard of living. What has made all this possible? Engineering. Look at the marvels of America today; analyze them and you will find that engineering is the basis of practically all of it. Engineering has even taken over production on the farm. The tractor, hay drier, separator, milking machine—all are engineered devices, many driven by electric power.

The new automobile, television wonders, buildings, roads—all are engineering accomplishments. What will develop out of atomic energy will be dependent on what engineers can do with it.

Look at the last war with its airplanes, tanks, radar, superguns, bombs. All were engineering achievements, and war in the future would be even more a matching of engineering skill. We must devise ways of making each man a more effective fighter. The enemy has superiority in numbers of men today, so to offset this disadvantage we must make every man we have more effective. We must use our brains to produce a war machine in which each man, plus machines, gives a superior productive and fighting force.

Our greatest problem today is to make the public understand the need for superior engineering and for engineers to produce the weapons and service and repair them and keep them effective war machines.

The public must understand that an engineer working on essential production is a most important cog in the wheel of making an effective fighting force. As engineers, we must work at the job of securing professional recognition, and in order to do this we must build the professional stature of every aggressive engineer in the country today.

Russia has graduated 30,000 engineers per year, with the equivalent of a master's degree, and 60,000 technicians a year over the last five years. In this country, engineers are in short supply and the outlook is very depressing. We will graduate 32,500 engineers in 1951; 22,000 in 1952; 17,000 in 1953; and 13,000 in 1954—if the draft does not interfere. We know that in the last two months prior to a directive by Selective Service a lot of these boys enlisted, so these numbers are probably quite optimistic. We need in this country today 30,000 engineers per year for both industry and the armed forces. With normal attrition we must have 60,000 engineers per year enter schools in order to secure 30,000 graduates. Half of this loss is for economic reasons and the remaining half is for various other reasons. A study of these figures shows we will be short 40,000 engineers by 1954. The Bureau of Labor Statistics' figures indicate that there are 400,000 engineers, 80,000 chemists, 12,000 physicists, 30,000 in the biological sciences, and that the grand total for scientific personnel is 575,000. Each year, through retirement and death, 10,000 engineers are lost to this country. So you can see from these figures that if we are to progress as a technological nation, we must do everything we can to build up the number of engineers and that therefore there is a great opportunity for engineering at the present time.

With respect to the draft of engineers, social pressure no doubt makes the greatest inroads. We can see this all around us in the newspapers and in some of the discussions that are taking place at the present time. There is not a

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Essential text of an address given at a banquet at the North Eastern District Meeting, Syracuse, N. Y., May 2–4, 1951.

A. C. Monteith is Vice-President, Westinghouse Electric Corporation, Pittsburgh, Pa.

real understanding of the essentiality of engineering in the present crisis, either for industry or for the armed forces.

There are several situations that require our attention today and I would like to discuss briefly four of these, namely, the draft, the situation with respect to reserve officers, the Engineering Joint Council (EJC) program, and the program of the Engineering Council for Professional Development (ECPD).

WHAT IS BEING DONE

CONSIDERABLE WORK has been done attempting to get Selective Service to recognize the situation outlined in this article. This work has been reflected in new manpower legislation, which is much better than some had originally anticipated. It does not specifically include universal military service and training, which seems the correct move at the present time. I am a firm believer in the general philosophy of general universal military training and service, but it should have been started in 1945, at which time we would have relieved the heavy burden of training that was placed on our schools and at the same time started a backlog of military people for the protection of this country.

The new law recognizes the importance of having someone who understands industry and the scientific requirements be the final advisor on deferments rather than leaving it entirely in the hands of the local draft boards. Advisory committees have been appointed in Washington to screen the deferments and to get the proper balance between the civilian requirements and the armed forces' requirements. Of course, Reserve Officers Training Corps will continue and will be the main artery for keeping the armed forces supplied with technical personnel.

The most serious situation in this country today is that of the status of reserve officers. EJC made a study of this situation and found that 25.6 per cent of the engineers in this country are in some form of reserve status. These are the men who are now in key positions doing engineering work, and it would cripple the country if these were taken from industry for the armed forces. EJC is working to bring this to the attention of the Defense Department and thus secure a plan whereby those in strategic industries can receive consideration for deferment.

EJC has now recognized the seriousness of this situation with respect to engineering, and has appointed a Manpower Commission to work out the various details of a program to alert high schools and parents to the situation, to alert industry, and to work with the Government groups administering federal policy. EJC plans on holding a manpower convocation in Pittsburgh in the fall to alert all of the engineering societies to their program.

The engineering profession must foster individualism if we are to progress. In the last two years ECPD has developed a program which will shortly be implemented throughout the country. This program is based on the fact that the young engineer must be ready to work before any program will be effective. A six-point program has been prepared to bridge the gap in the first five years after graduation, and in this way start a healthy professional attitude in the engineering fraternity.

It has been my pleasure to be Chairman of the Committee on Professional Training of the ECPD. We have attempted to organize a guide for the many groups who have responsibility in the development of the young engineer. At the outset, we are concentrating on suggestions for the first five years after the man has graduated from college. I believe this is the most important five years in the man's professional life because he is for the first time on his own. If we can round out a program that will assist him in organizing his thinking rather than let him become confused by the complexity of the present day, we will have done a great deal toward helping him become a leader in the last half of the 20th Century.

RESPONSIBILITIES OF THE INDIVIDUAL

THE COMPLEXITIES of modern business require the employment, in increasing numbers, of college graduates with a technical background and a broad professional outlook. While the craftsman of former years grew up with the business, the college graduate of today steps into a strange organization at a relatively high level. He has had no opportunity to understand, through long association, the methods and operation of the concern. During his first few years with the company, the young engineer is finding his place in the organization, attempting to understand himself, and shaping his professional goal. Frequently, he is establishing his family, and generally his salary is modest. Closing the gap between his experiences on the campus and the realities of earning a living in a complex situation is not an easy task. Obviously, he needs assistance in making the transition from directed development to self-development. He should, however, be ready to assume his full share of responsibilities and to put himself into his job before looking to others or being critical of others for not assuming their responsibility toward him.

A few characteristics, which should be inherent in a young man if he is to progress, follow:

1. He should have his mind fixed on a definite field of endeavor but should allow some flexibility in his thinking.
2. He should be loyal to the company he works for.
3. He must realize early in his career that interest in his job is paramount. Lack of interest causes the loss of more opportunities than lack of knowledge.
4. He should be willing to work. Not just the performance of assigned tasks, but extra effort to improve and broaden himself through outside reading, further study, and supporting his profession by attending and taking an active part in its association meetings.
5. He should be encouraged to be a team player. The ability to get along with people in our complex civilization is vital. Emphasis should be placed on getting the job done, rather than on doing the job personally.
6. He should have determination.
7. He must expect that his mistakes will be noted.
8. He must be encouraged continually to analyze himself on all matters, but especially to be sure he understands his objectives.
9. He should be encouraged to accept responsibility.

10. He should be encouraged to be a business man in a business organization, acting like a mature person, and above all being natural.

During his first 5-year period, the greatest factor the graduate engineer has to overcome is impatience. I do not mean to infer by this that the young man should not be continually appraising himself and the position in which he finds himself, but rather, in an engineering way, he should be sure that the distant fields are really greener before he sets out to them. I have observed cases where impatience has blinded the graduate to the opportunities that were all around him.

So much for the individual himself. What are some of the responsibilities of others in seeing that he develops at a satisfactory pace?

ORIENTATION AND TRAINING

THE EMPLOYER should recognize that there is no direct teaching method that can do the entire job of developing the engineer professionally. Experience and accomplishments, both functions of time, play, too, as important a part in ultimate arrival at the goal of professional status. It is only through good training, proper guidance, and continuous encouragement that the graduate engineer will even be motivated to work at the many things that can increase his professional status.

The company should have lectures given by executives and other key men, show films of its products and plants, conduct tours of the plant, and give a history of the company and a summary of its policies and the opportunities it offers.

A training schedule should be set up, geared to the size and type of company. Some companies have definite schedules of training assignments while others shift men from job to job on a regular basis. Many companies include classroom training or conferences during or after regular working hours, accompanied by written examinations and reports. Some are now using a rating system so that a quick check is available on the over-all performance of each man. This orientation and training period lasts from three months to two years in various companies, depending on the magnitude of specialization to which they carry their operations.

Contrast this with the direct employment case, that is, hiring an engineering graduate for a specific job with no intervening training period. He starts becoming a productive employee the first day and often many years pass before he learns, piece by piece, what the over-all company operation is and how it is organized. He learns the hard way what facilities and services are available to him, and he may make many embarrassing mistakes. He feels rather lost in a strange world during his first few years and does not realize where his opportunities may lie. This is the kind of situation that most frequently causes the "postcollege slump." A good training course, administered with understanding and sincerity, is a potent instrument creating healthy attitudes necessary for the engineer's professional rise.

The key to good work is job satisfaction. Management realizes that satisfaction depends, in a large part, on whether the job draws on all the professional talents of the employee. Too frequently men and jobs are thought of as round or square, but they are many different shapes from the standpoint of aptitudes, abilities, and interests. Flexibility in arranging jobs so that activities are fitted around the man rather than forcing him into the mold is advantageous when dealing with the mature engineer, both from the standpoint of productivity and morale. This picking the man for the job is one of industry's greatest responsibilities in training and developing new personnel.

Frequently we hear the comment: "Fine, but a small company cannot afford much of what you are talking about and, therefore, cannot assume such responsibility." With this opinion, I heartily disagree. As a matter of fact, a small company taking on only one, two, or three graduate engineers a year has the greatest opportunity possible to personalize their orientation and training period. Because their organization is small, closer contact with the men of experience and leadership in the organization is more possible than in the big company. Elaborate classroom setups, so essential in the big company, are not necessary in the small one. ECPD has suggested a training system for small, medium, and large companies as a stimulant to even more training than is now being done.

Many employers use the "sink or swim" approach for getting the young engineer to perform at top level. Wisely employed, this can be a good policy. I believe that while the young engineer should be out beyond his depth much of the time, he should occasionally get an opportunity to kick his foot on bottom; or if he gets into a real hole, someone should throw a life preserver to him, but this latter must not be overdone. He has a heavy stake in this process and must realize his responsibility. He can, however, be taught some fundamental swimming strokes before he is thrown in over his head.

CONTINUED EDUCATION

UPON ENTERING his new job, the aggressive engineer soon finds that education is a journey and not a destination. Immediately he will start planning his continual improvement. This is one place where industry, the colleges, and the societies can fill a void in the young engineer's life. He should be encouraged to read extensively, both professional and general literature; to take courses that will broaden him; and to become a part of his professional society.

The idea of providing educational opportunities for industrial people is taking hold. Several types of programs were investigated by the ECPD Committee on Professional Training. They include programs of management development and general education. The Committee found that in 14 or 15 areas in this country, fairly extensive adult and professional education programs exist. If there is any criticism of such programs it should be directed largely at the fact that they tend to be more of the advanced study type rather than courses that broaden the man from a managerial or civic point of view.

The study has disclosed that in most of the areas now carrying on this type of work, the co-operation is largely

between the large companies and the universities. This offers a real challenge to the societies not only in those particular areas but also in many other areas where the society could organize such a program, making it available to large and small companies alike. If such is done, the Committee believes that it should be this joint action by the societies, the schools, and the employers so that the courses will tie in, and they will get credit toward an advanced degree in all branches of engineering. This suggests that the Engineering Council take the lead in those areas where it exists. In most cases where the societies are now sponsoring such programs, they are not tied in with educational institutions and, therefore, graduate credit is not available. I do not suggest that graduate credits are a necessity. They are not. Rather, they are an incentive to many recent graduates. At Westinghouse we find that for each man who takes a course in order to get an advanced degree, 20 take them solely for their own edification and betterment.

COMMUNITY INTEGRATION

The integration of the young engineer into the community is a social matter much neglected. The engineer is notably backward in his participation in civic developments and programs. In many cases he is working for someone and, therefore, leaves it to the employer to develop the community relationship. The engineering graduate seldom obtains employment in the community of his boyhood or college, so a new job means a physical as well as a mental adjustment and change. Even in the smallest company or enterprise, some preparation has been made to welcome the new engineering employee. In very few cases, however, has anyone or any group made similar plans to introduce him into his community and its activities.

While many industries have been quite active in promoting and encouraging athletic and social programs, few have considered it their function to be at all concerned with the church associations of their employees. Some companies have now found it desirable to keep in touch with local ministerial associations, advising them of new additions to the community. Most churches have organized social groups as well as regular religious activities, so in at least two areas the newcomers feel a part of the community.

Responsibility for integrating the young engineer into his community has been at various times assigned to industry, the community, the technical society, or left to the individual. Actually, it is the joint responsibility of all four.

SOCIETIES' RESPONSIBILITIES

In the past, the societies have viewed themselves largely as organizations to promote technical discussions and developments. The societies have been missing a real opportunity to serve the young engineer; I do not mean on a national basis, but rather at the local chapter level. I stress this last point because the young engineer is not in a position to attend national meetings and he must of necessity look to his local chapter for contacts. The societies, therefore, have a real opportunity for co-operating with local industry in seeing that continued education is made available to their membership, that the engineer is integrated into the community, and that society activities of a technical and social nature are made available to him.

The man himself also has an obligation in this connection. When such is made available for him, he should participate, and if it is not meeting his needs, the society would certainly be most attentive in listening to his constructive criticism.

"Why," you might ask, "should the societies, the schools, and industry be interested in an undertaking of such magnitude as discussed tonight?" Earlier I pointed out that we are now entering into the most specialized type of civilization the world has ever known. And we are moving at a terrific rate, not only in production and production processes, and in development of new ideas, but in the development of even new branches, such as the whole new phase of atomic energy. We must have available a force of technical people who can back up our armed forces in another war. Our whole life is becoming very closely linked to technical development and progress. One might say that the survival of this country is dependent upon the development of good technical people. What we want and need in this country are men who are thoroughly trained in their particular lines to the point that they are individuals and free to think individually. This concept is fundamental to the free enterprise system on which all American business is founded. So, let's as a society or a community, or as employers, do everything we can to bring our young engineers up in their profession so that they will have a feeling of professional pride and will be able to talk, act, and think as individuals. We owe the rising generation of engineers the best possible guidance and training that can be given to them because they, in turn, are going to have to assume the responsibility of bringing the next generation into an even more complicated way of life.

It is my fond hope that now that the ECPD program is developed to the point of having a good guide on professional training, we will somehow find the money to employ a man who can devote all his time to building up broad programs in the many areas that now have no program for the young man in the way of professional training. Thus, we will help the young man attain, at a maximum rate, full professional stature.

So the schools, corporations, communities, and societies have one objective: to do everything possible to help the young man to rapidly attain full professional stature, provided, of course, that the young man realizes that he must contribute heavily to the program. He will get out of it in proportion to what he puts into it.

To the young engineers I want to say that there is opportunity all around you. Organizations are ready to receive you with understanding. As Mr. A. W. Robertson, chairman of the Board of Directors, Westinghouse Electric Corporation, brought out in a recent talk, you can be either an oyster or an eagle. The oyster fastens himself on a rock and lets the ocean waves feed him. He has no backbone nor outlook on life. The eagle has his home on barren rocks, high up on the cliffs. He must work for his way of life. He is respected in the animal kingdom and has a far-sighted outlook on life. Do you want to be an oyster or an eagle? It is up to you.

Electrostatic Charge Statistics

FOSTER FRAAS O. C. RALSTON

THE BASIC PART of a common form of electrostatic separator is the rotating cylindrical electrode A of Figure 1. A granular material is fed from hopper W by means of the vibrating conveyor E onto A. The rotation of A carries the particles through some form of an electric field where the particles are deflected in accordance with their electrical properties.

Electrode A is usually at ground potential and the electric field is generated by an adjacent electrode B at high potential. This electrode may form a field of ions which charge the particles, or it may form an electrostatic field that is as free of ions as it is possible to obtain. In either case the deflection away from A is dependent on the interfacial particle-electrode conductance, and a separation is secured by adjusting the dividing edge G to a suitable position so that the poor conductors are collected in N and the good conductors in C. This article deals with a separator having a "pure" electrostatic field with negligible ionic leakage between electrodes, and with the separation dependent on the differences in the conductance of the particles. Although all the particles may have the same weight and specific conductivity, the interfacial conductance varies through a range of values. This decreases the sharpness of the split made by dividing edge G.

The nature of the distribution was determined by measuring the charges on the individual particles. Charges were measured as the particles from the grounded carrier electrode fell through a Faraday cage which was insulated from ground and connected to an *FP54* thermionic electrometer. Both the cage and electrometer were in a grounded metal box. The cage was placed close to A so that the time of fall through the cage was sufficiently long and all the particles throughout the range of deflection angles were intercepted. The particles consisted of crushed galena having a size range so that they passed through a 2.36-millimeter opening screen and were retained on a 1.65-millimeter opening screen. They varied in weight from 35 to 100 milligrams each.

The particles thus were counted in groups classified according to the magnitude of the charge. By plotting these data on probability paper the charges are shown to be distributed as a logarithmic function of the normal law.

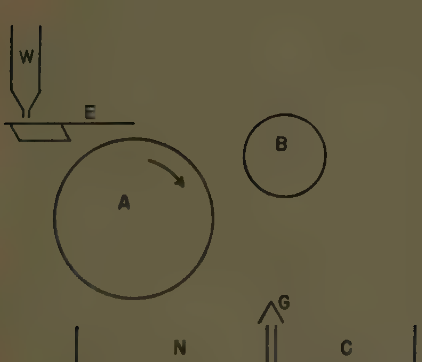

Figure 1. Diagram of electrostatic separator

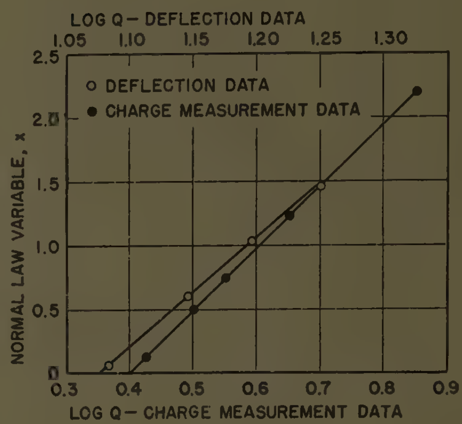

Figure 2. Graphical proof of normal law distribution

Additional data on the distribution of the particles may be secured by substituting a horizontal compartmented box for the dividing edge G, each compartment receiving particles from a limited horizontal range. A common graphical relationship is the straight line formed when the number or weight of particles deflected to each compartment is plotted on a logarithmic scale versus the distance on a linear scale.

The charge on the particle determines the distance to which it is deflected, or the horizontal position of dividing edge G where it would be intercepted. From the form of the electric field and the cylindrical electrode A, a complicated expression relating this distance to the charge would be expected. However, a similar semilogarithmic plot of the charge measurement data, charge being substituted for distance, indicates that a linear relationship between the charge and distance may exist. A final calculation and graphing of the trajectories shows that theoretically the distance is a linear function of the charge over a small but significant range of distance. A further check between experiment and theory is the identity of this range with the linear range which occurs in the semilogarithmic plot of the deflection data.

Using the derived expression relating the distance to the charge, deflection data from separator operation now may be calculated in terms of charge. In Figure 2 the logarithm of the calculated charge for chromite sand is plotted versus the normal probability law variable x. The normal law variable is derived from the distribution percentages by means of the table of values for the integral of the probability function. Also shown in Figure 2 is a plot of the data derived from the direct measurement of charge on galena particles.

Digest of paper 51-202, "Distribution of Charge in Electrostatic Separation," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Report on Co-operation between the Electric Power Industry and the AEC

AD HOC ADVISORY COMMITTEE* TO THE UNITED STATES ATOMIC ENERGY COMMISSION

As the largest potential user of nuclear reactors, the electric power industry must seek to maintain full co-operation with the Atomic Energy Commission in the development of atomic power. This report is a study of some areas of common interest and suggests some methods for continued co-operation.

THE LETTER from the Atomic Energy Commission (AEC) which designated the three members of this group as an Ad Hoc Advisory Committee asked us to become acquainted with the projects and technological roblems of the AEC reactor program with a view to ecommending a workable plan for . . . cooperation with ıe electric power industry which will most effectively erve the needs of the Commission" and that industry. 'he assignment was somewhat amplified in the terms f reference which are appended to this report.

The phrase "electric power industry" means the electrical tilities, both publicly and privately owned, which produce r distribute electricity for ublic use. The utilities are oncerned with nuclear reacors and their development ı somewhat the same way hat they have been and still re concerned with research nd development on boilers, urbines, generators, heat xchangers, and the other onventional types of power quipment, and with fuels and their processing. Generally peaking, the electric systems have not found ways to give ffect to their interest in this new field because security estrictions and the requirements of government monopoly ffer such formidable obstacles to traditional industrial articipation.

The situation of the utilities is in contrast to that of such lasses of concerns as chemical and equipment manuacturers. The impact of security requirements and Commission monopoly is minimized for these concerns ecause they can become AEC contractors for substantial hases of reactor development and thus be an integral part f the atomic enterprise. Examples are the power equipnent manufacturers, a group not included in the term electric power industry." As the original AEC letter o us recognized, the electric power industry, whose rimary function is not to manufacture but to utilize quipment, does not have the same opportunities to articipate in the reactor program through contract perations. The Ad Hoc Committee was, therefore, set p by the Commission in order to help find other means to ring the utilities into active contact with the atomic enrgy enterprise.

In preparing this report we have avoided inclusion of any classified material. We were given access freely, however, to the secret as well as nonsecret information relevant to our study, and this opportunity has been essential to completion of our work. As suggested by the Commission, we visited most of the installations where major research and development was being carried on. We also had numerous conferences in Washington and at these sites and elsewhere with the staffs of the AEC and its contractors. We wish to express our appreciation for the generous assistance which these groups gave us at all times. In particular, we want to thank Dr. Lawrence R. Hafstad, Director of the Division of Reactor Development, for his personal interest in our work; Mr. James K. Pickard, of his staff, and Mr. William A. W. Krebs, Jr., of the AEC Legal Staff, who accompanied us during some inspection trips and attended a number of our conferences; Dr. Robert Oppenheimer, who extended the hospitalities of the Institute for Advanced Study at Princeton for our final discussions; and Mr. Herbert S. Marks, a former General Counsel of the AEC, who advised with us during that stage.

POWER INDUSTRY'S INTEREST IN ATOMIC POWER

THE SPECIAL INTEREST of the electric power industry in the Commission's enterprise derives from the prospect of utilizing atomic power for ordinary central station purposes. If this prospect becomes a commercial reality, then—aside from weapon production—the power systems of the country could be the largest potential users of nuclear reactors just as they are today the largest users of fuel fired steam boilers. Similarly they could become the largest potential users of nuclear fuel, just as they are today the largest single user of coal.

Whether and when atomic power becomes commercially feasible depends upon the Commission's nuclear reactor program, a program which—except for the piles producing plutonium for bombs—is still in the research and pilot plant stage. While none of the reactors which are part of the present AEC program have been designed primarily with an eye to industrial power production, they will give, as the Commission has indicated, "impetus to the ultimate use of nuclear energy" for such purpose. The AEC-Westinghouse Electric Corporation land prototype for a submarine propulsion machine is well under construction at the Reactor Testing Station in Idaho; the

Members of the Ad Hoc Advisory Committee are: *Chairman*, Philip Sporn, President f the American Gas and Electric Service Corporation, New York, N. Y.; E. W. Moreouse, General Public Utilities Corporation, New York, N. Y.; and Walton Seymour, conomic Co-operation Administration, Athens, Greece.

companion project, for which the General Electric Company is contractor, soon will be under construction; and we are encouraged to believe that before many years one or both will actually be operating a submarine. In another sense, the Material Testing Reactor, scheduled for operation at the Idaho site, should also greatly advance fundamental reactor technology.

We were impressed, too, by the homogeneous reactor at Oak Ridge which promises to illuminate several key problems relevant to the eventual development of a practical power reactor, and by the hopes in the possibility of nuclear breeding. If, as one member of the Commission remarked the other day, "the intriguing possibility of nuclear breeding can be made a reality . . . it may very well give us a reduction of cost of atomic power to where it can compete with our other sources." While the prospect of breeding has the most dramatic appeal, there are other possibilities with more limited implications. For example, the ideas being studied just now for combining production of plutonium for weapons with utilization of by-product heat energy, although perhaps not economical for power production generally, may be feasible for specific projects under conditions where, as now, the military need of the prime product plutonium gives it a special monetary value.

It is clear to us that no valid judgment can yet be made as to whether and on what scale nuclear reactors will ultimately contribute to our energy resources. Nevertheless, our own observations, reinforced by recent pronouncements of the AEC, convince us that the prospects of an important new source of power within the next decades are robust enough to warrant a strong present and continuing interest on the part of the electric power industry. This is not because conventional methods of producing power are unsatisfactory. On the contrary, Commissioner Pike accurately described the situation when he said recently, "Because of our natural endowment of large amounts of cheap coal, oil, and natural gas, and our continuous developments and techniques of large scale power production units, we have set a very difficult mark for any new source of power to meet." But the same conditions which helped bring the art of conventional power production to its present stage also foster an interest in a new source of heat energy potentially capable of providing a further advance in the art.

Electric generation in the United States has been predominantly dependent upon steam, that is, upon fuel, and it will certainly continue to be heavily dependent upon heat energy. Hydro power, though substantial, can provide only a part of our rapidly growing requirements because the remaining undeveloped water power sites are limited. The industry today requires in the operation of its steam plants fuel equivalent to about 100,000,000 tons of coal annually—roughly one-sixth of the country's coal consumption. Demands for power have been expanding and will continue to expand dynamically. Capacity has doubled on the average every decade for the past 40 years, and it is reasonable to believe that this will happen again in the next ten years, and that a substantial rate of growth will continue thereafter. A variety of factors, not least of which is the close attention to improvements in technology, have enabled the electrical industry to keep costs of service to the consumer on a more or less steadily declining curve, even during the past decade when other costs were rising sharply.

Therefore, the industry should be strongly attracted by any prospect for the production of heat energy which might bring about a material lowering in cost of steam power production. In saying this no one should expect that commercially feasible atomic power would mean radical reductions in power costs. If nuclear reactors can produce heat energy for power plants, that energy would replace the fuel element in conventional electric generation but with some increase in capital costs. There is little, if any, prospect that the over-all cost reduction could be revolutionary, but the results could be significant, especially for a number of industrial operations which any appreciable lowering of power costs would stimulate. Examples are reduction of magnesium and aluminum, refining of copper, production of cement, chlorine and caustic soda, and like operations where electric power represents a relatively substantial part of the cost of the finished product. Significant economic consequences also might be anticipated through the development of new uses of electricity in industries where the application of power to industrial processes may now be retarded by cost factors.

Quite apart from the possibility of cost reduction through nuclear reactors, such a new source of heat energy might afford advantages in compactness relative to conventional fuels and in the extensive supplies that would become available if breeding is perfected.

The fact that the possibility of commercially feasible heat energy from nuclear reactors cannot be realized for some years or longer ought not to weaken its attraction for the electrical industry. A constantly expanding market, the large capital expense required to meet the demand, the relatively long cycle for installing new facilities, and the long life of equipment have accustomed the industry to look and plan many years ahead.

The nature of the industry's interest in nuclear reactors also can be stated in terms which describe its role in the changing technology of conventional power production: in order to make wise current plans and prudent investments for the future, the industry must at all times keep abreast of developments relating to power production and what they foreshadow; in order to keep costs down and improve service, the industry must contribute as directly and as effectively as it can to promoting advances in technology.

In the field of conventional power production the industry is able to give effect to these interests through its working relationships with the manufacturers of power equipment, producers of fuel, and with the other institutions where research and development is carried on. Today, for example, a 38 per cent thermal efficiency is achieved in the best of the new power plants; a few years ago the efficiency of the best plants was only 13 to 15 per cent. The present high thermal efficiency may be credited fairly to the joint efforts of the manufacturers and the electric systems who constantly collaborated with one another in

nproving the art. The accumulated operating experience f the electric systems and their special knowledge of their wn requirements and those of their customers have been ombined through the years with the special knowledge and acilities of the manufacturers to produce from year to year ew and better types of equipment.

A major contributing factor in the process just described as been the practice of the members of the electric power ndustry, in contrast to most other industries, to share heir technical and operating experience fully and freely vith one another. This practice has tended to quicken he pace of technological development.

Perhaps most important from the standpoint of the tilities, their collaboration with the manufacturers and vith one another has enabled them to become informed of he latest developments as they occur. It is only as a part f this process that they are able to evaluate reliably the rospects for still other improvements in the future. All his knowledge in turn becomes a key to the planning which he electric systems do in order to meet the constantly xpanding demand for power, to promote new and better ses of power, and to keep costs down.

What we have just described is the traditional participa-ion of the electric systems in the technological process f developing conventional power equipment. This proc-ss, which has been beneficial to the electrical utilities, to ther power producers, and to the manufacturers of equip-nent has for its ultimate beneficiary the public at large.

We take it to be an objective of our industry and the Commission to create conditions governing the electric ower industry's relation to nuclear development which vill be as nearly like these normal conditions as may be onsistent with the requirements of security.

AREAS OF MUTUAL INTEREST TO POWER INDUSTRY AND AEC

To DESCRIBE THE electrical industry's concern with atomic energy is to see only one side of the picture. There is also a pervasive community of interest between he Atomic Energy Commission and this industry, essen-ially because the electric systems are likely to be the rincipal medium for distributing to the public whatever enefits are to flow from nuclear fuel. In order to turn his mutuality into a constructive working relationship, our erms of reference contemplated that we should "study the Commission's reactor program with a view to identifying reas or potential areas of mutual interest." It seemed easonable to expect that as these areas were discerned and lescribed the elements of a program of contacts advan-ageous to both the industry and the AEC would suggest hemselves.

During our survey of the Commission's reactor projects ve noticed striking analogues to a variety of the problems vhich the electrical industry and the manufacturers had ncountered as the art of conventional power production dvanced. These common elements included such items s the design of pressure vessels, of coolant systems (and ontrol of purity of coolants), of pumps, piping, and heat ransfer systems; the electrical, mechanical, and civil ngineering aspects of reactor plant construction; fuel preparation and ash handling; control and instrumenta-tion; and the general relationship between reactor operat-ing characteristics and those of conventional electric power plants.

In the collaboration between electrical industry tech-nicians and the manufacturers of power equipment, the operating experience of the former frequently has been drawn upon in solving problems of this type. Our dis-cussions with the personnel associated with the reactor projects suggested that a similar joint approach to these Commission problems would be welcome and useful. The extent of the industry effort that would be required for this purpose is indicated by our estimate that during the next several years the reactor program could profitably utilize the temporary services of about 25 technicians per year from the electric systems of the country. The form which this collaboration might take, the precise method of pin-pointing the trouble-spots to work on, and the method of selecting the individuals to do the work are discussed later.

There is, however, a broader and more important area of mutual interest than these specific technical problems. As the Commission's reactor program proceeds, it will become increasingly necessary to make realistic appraisals of the potentialities of reactor projects as parts of electric power systems. The more closely the Commission ap-proaches its goal of a successful power reactor, the more compelling will be the need for these over-all engineering-economic judgments.

In the meantime, the soundness with which selec-tions are made between a variety of alternative paths to the ultimate end will depend upon how well judgments of the same general kind are made.

These analyses will require not only the talents of the physicists, chemists, and chemical and mechanical engineers who are engaged in the Commission's reactor program but also the talents which now reside in the system planning engineer, power supply engineer, transmission engineer, and in the utility management experts, who have re-sponsibility for utility economics in the electric power industry.

The application of the body of knowledge and experience called utility economics is a major function of the industry's management and engineering personnel in the decisions which have to be made constantly in maintaining and expanding power networks. The issues which are dealt with in this field involve the balancing of all the many factors entering into final cost in an operation in which a great many variables can be introduced, to give an over-all most economical result. Not only are choice and determination of emphasis made between capital or fixed, and operating or variable, costs, but the effects of different rates of depreciation of the various schemes are evaluated. And there is always present the question of how far to go in extra expenditure on projects being created today to avoid heavy losses or heavy expenditures on expansion of those projects 10 or 15 years from today; these questions alone are most difficult, but their consideration invariably raises a host of subsidiary questions of great difficulty and complexity—well illustrated by some of the problems which

confronted the utilities who recently submitted proposals to supply the Commission's Paducah Project.

There is a need to bring similar techniques of analysis and judgment to bear on aspects of the AEC reactor program. In pursuing the idea of a nuclear reactor for the production of plutonium and by-product heat-energy for power, this type of appraisal is pointedly relevant. The problem will become increasingly complex and pressing as the time approaches when a nuclear reactor is designed primarily for the production of heat energy for a power plant. The Commission then will require more and more refined analyses of such important items as: capital costs of reactors and their complementary parts to give total investment costs in a complete system of electric power generation; dependability of reactors, that is, the proportion of the time that the reactors would be reliably available for power supply at full capability; costs of reactor maintenance; costs in starting and stopping units; costs of feed material and handling of feed material, including prospects as to cost and availability of such fuel at least covering the period of the economic life of the initial investment; the problems of integration of nuclear power into existing power networks; and finally the over-all cost, both capital and operating, of the power obtained from such nuclear reactors and the relative advantages or disadvantages of such power as compared with that from other competing sources for which, if economical, it would be substituted.

Both the Commission and the electrical industry have a stake in assuring a sound approach to these problems. Reliable, illuminating system analyses will enable the Commission to maintain a more direct course toward its ultimate goal; and for the industry, the more competently these problems are dealt with, the more effectively the electric systems will be able to integrate power reactors, if and when they are feasible, into the highly organized system of electric supply which characterizes this country's economy.

This area of mutual interest—that is, the domain of utility economics—impresses us as the most important in which to establish contacts between the Commission and the industry. It is also the most difficult because of the time required to create effective working relations between groups within the AEC enterprise and the industry and to build up the joint body of knowledge and experience which is the prerequisite to useful appraisals and judgment. The program of continuing co-operation which the AEC asked us to help devise should have as one of its main objectives the formation of such working relations and the building up of such knowledge and experience.

A PROGRAM OF CONTINUING CO-OPERATION

The AEC Industrial Advisory Group's report of two years ago "placed primary emphasis upon increasing industry's knowledge about atomic energy." It was the strong view of that Group that "as industry acquires a larger share of organized, detailed information . . . industry and the Commission, working together, will find many ways of increasing industry's part in the enterprise." Recent events are beginning to bear out this theory.

An example is the recently approved project for reactor feasibility studies by The Detroit Edison, the Dow Chemical, and the Monsanto Chemical Companies. The Commission remarked in approving them that "these proposals appear to offer not only an opportunity for bringing new technical and management resources into the atomic energy program; they also are oriented toward important Atomic Energy Commission objectives—the production of plutonium and other important materials, together with power, in a reactor; and they may ultimately lead to arrangements where, because initiative is with industry, additional incentives for rapid and aggressive technical and business development will exist."

For our purposes it is an equally important point that the industrialists who sponsored these proposals were men who had previously had absorbing contacts with atomic energy. Their connection with the enterprise began long before they presented their ideas to the AEC; without such contacts their proposals could scarcely have been conceived.

In order that the power industry may attain a part in atomic energy at all comparable to the useful role it has had in the development of conventional power equipment, it must first become educated about the subject. One opportunity along this line which it is up to the industry to take advantage of is the Commission's Oak Ridge School of Reactor Technology which has just announced its 1951–1952 session. Here, as the most recent AEC release points out, qualified trainees from industrial firms can secure a substantial background in reactor technology and allied subjects. We would hope and expect as time goes on that personnel from the electrical industry would seek admission to sessions of this school and that the school would emphasize those features of training which would make it worth while for such personnel to attend.

Another valuable type of educational experience is that to be secured by power industry technicians as a by-product of assignments to assist the Commission with the specific technological problems referred to in the preceding section. It was our estimate that during the next several years approximately 25 such technicians per year could be used effectively on a temporary basis by the Commission on problems of coolants, heat transfer systems, and so forth, where electrical industry experience seems peculiarly relevant.

As they return to their own companies, the men assigned to these specific technical jobs (as well as those who attend the Oak Ridge School) would form a reservoir of informed personnel. The mere existence of such a group would enhance in numerous ways the opportunities for other constructive contacts with the atomic energy enterprise and the capacity of the industry to evaluate developments.

The mechanics of finding power industry people for these temporary Commission assignments brings us to the question of a permanent industry committee, a matter about which the Ad Hoc Committee's terms of reference requested our opinion. We believe that a permanent committee should be set up and suggest that its first assignment should be to provide organized power industry assistance to the various Commission projects in identifying the places where industry personnel could be helpful and

to locate the personnel within the industry who might be detailed to fulfill these needs.

At least in the beginning, the Committee's role should be conceived in quite simple terms. Like the Industrial Advisory Group we can see the usefulness of the industry committee device. But we agree also with the view of that group that it is easy to exaggerate the direct assistance that such special committees can give the Commission. They can be valuable "provided they are viewed in perspective as but one modest feature in solving the immensely large and difficult problem of industrial participation in atomic energy." Certainly, initially, as the Industrial Advisory Group put it, "a principal value of the advisory committee idea lies in the education of industry."

Bearing these qualifications in mind, we recommend an industry committee that would be broadly representative of the electric power industry. Membership of 10 to 15 individuals would accomplish such representation, while keeping the size within manageable limits. The members should be drawn from the top executive ranks of the electric systems; at least a substantial portion of them should have some engineering background; and staggered terms of membership are desirable so that over a period of years a larger number of industry executives could have the experience of membership. All members of the Committee should be cleared. Presumably they would meet according to some more or less regular schedule and would have the assistance of minimum staff facilities. If the Commission wishes, we are prepared to discuss the details concerned with the setting up of this permanent group.

The Committee members should be given an opportunity to familiarize themselves with the reactor program and other relevant phases of the Commission's enterprise. In the first instance a visit to Commission installations similar to that afforded the Ad Hoc Committee would be informative and educational to them as it was to us. We believe that this could be arranged in such a way that it would not cause serious inconvenience to the Commission's staff.

After the Committee gains some experience with the enterprise and after it has assumed its first task of bringing power industry technicians into the specific parts of the Commission's works where such assistance is needed, it should then take on a second assignment. This should be essentially a responsibility to make reports to the power industry to keep it abreast of developments in the atomic energy field and of their implications. These reports would have to conform to security requirements, and it would be necessary that they be carefully reviewed for accuracy of statement and interpretation. But it is clear to us that such nonclassified reports supplementing the general reports which the Commission now publishes could be of considerable value to the industry. The Commission's present reports are geared to the public at large or to the Congress. The information which the power industry most needs would be of a sufficiently different character to warrant considerable effort on the part of an industry committee to formulate and present them. Some of the reports could be written, but oral reports at industry meetings which the Committee might arrange are also desirable. In the course of developing these reports, we believe that another aim of the Commission, also stated in our terms of reference, would be furthered, namely the identification of additional declassifiable information regarding reactor development which might be useful to the industry as a whole.

As contacts develop along the lines described in this section, further measures of mutual value will suggest themselves. Additional proposals like the current Detroit Edison Company reactor feasibility study should certainly be welcomed to the extent that the conduct of such studies does not infringe on other pressing AEC work. We would expect other proposals along these lines to emerge as the numerous segments of the industry build up closer relations with the enterprise. The permanent industry committee should not only play an important part in catalyzing and helping shape such projects but may possibly become the instrumentality for setting up one or more projects participated in by the power industry as a whole.

Such projects, moreover, whether sponsored by individual systems or under committee auspices, probably represent the most practical initial approach to the problem of overall economic-engineering appraisal of reactor development and its place in relation to the general problem of power supply. As we have said, this, the domain of utility economics, impresses us as the most important area of mutual interest to the AEC and the industry. It is also the area with the greatest difficulties and complications. The techniques applied by industry management and industry engineers afford a method of approach to the problems in this field. The application of these techniques, which combine elements of art with those of science, should however not be attempted along the lines of any preconceived plan but should be permitted to evolve as the Commission, the Committee members, and the industry acquire a common body of experience.

The Atomic Energy Commission is now laboring with a program of immense size, variety, and difficulty. No one should expect—least of all the members of this group—that a body like ours could devise a plan of co-operation which would promise large, immediate advantages to the AEC's vast program or, for that matter, to the industry. There is, however, as we have sought to show, an important community of interest between the industry and the enterprise, and the cumulative effects of action with respect to the points of collaboration suggested in this report could be significant. We think it much less important to attempt to anticipate and describe just now the precise benefits which the atomic energy enterprise and the industry should expect from such a program of co-operation than it is to lay the groundwork from which some of these benefits may later spring.

Terms of Reference

1. *Membership:* Mr. Philip Sporn, Chairman; Mr. E. W. Morehouse and Mr. Walton Seymour, members.

2. *Objective:* It is the objective of the Committee to inform itself regarding the Commission's reactor development program in order to make recommendations as to the most practical means of establish-

ing effective continuing contact, within security limits, between the Atomic Energy Commission and the electric power industry.

3. It is expected that the Committee would study the Commission's reactor program with a view to identifying areas or potential areas of mutual interest to the electric power industry and the Commission and with a view to making recommendation for bringing about a continuing program of co-operation in these areas.

4. The recommendations of the Committee should include recommendations as to the need for establishing a permanent advisory committee for the electric power industry and suggestions as to membership on any continuing advisory or liaison body with this industry that might be desirable to implement the proposals of the *ad hoc* committee. They should include, also, comments regarding the development and utilization of technical personnel of the electric power industry, and other items of interest.

5. It is hoped that a program may be devised for contacts between the electric power industry and the Commission which will give to appropriate representative groups and technicians in the industry a current understanding of the problems involved in the Commission's nuclear reactor development work, thus enabling the industry to participate in properly defined areas of that work and to utilize its specialized technological resources to contribute to the solution of problems in this field for the mutual advantage of the Commission, the power industry, and the general public. It is also hoped that through this program it will be possible to identify declassified and further declassifiable technical information regarding reactor development which may be useful to the industry as a whole.

6. *Procedure:* It will be necessary for the members of the Committee to inform themselves as fully as is feasible regarding the terms of the Atomic Energy Act of 1946 and the AEC and Government policies and procedures which establish the frame of operation for the Atomic Energy Commission.

7. The Committee then will review the AEC reactor development program by means of an examination of work plans and technical data, visits to principal installations, and conferences with AEC and contractor representatives.

8. *Security:* Members of the Committee have been cleared for access to such restricted data, within the meaning of the Atomic Energy Act of 1946, as is necessary for the Committee's work. This does not include access to weapons data and data relating to rates and amounts of production. The Committee will conform to all security regulations and requirements of the Commission.

9. *AEC Staff Assistance:* The Director of Reactor Development will arrange for the AEC staff to provide the Committee with any necessary assistance in making field trips, obtaining background materials required, and, to the extent desired, in the interpretation of findings.

10. *Time Schedule:* It is expected that the Committee will have completed its review and will submit its recommendations by March 31, 1950.

Establishment of Corona Laboratories Announced by NBS

The establishment of a new National Bureau of Standards (NBS) laboratory center at Corona, Calif., to be devoted to various phases of electronic research, development, and engineering was announced recently. To be known as the Corona Laboratories, National Bureau of Standards, the new research center will be concerned primarily with technical problems of importance to the Department of Defense. The site was transferred to NBS by the Department of the Navy because of the Bureau's urgent need for new facilities. About 22 buildings are being renovated to accommodate NBS research and development activities being transferred there from Washington. Dr. R. D. Huntoon, formerly Chief of the NBS Atomic and Radiation Physics Division, has been named associate director to head the new laboratories, which are expected to be in essentially full-scale operation by this month.

The site has the advantage of proximity to other important research centers, especially the Navy installations at Inyokern and Point Mugu and the aircraft industries in the Los Angeles area. Eighteen months' to two years' construction time was saved because existing buildings at Corona were easily adaptable to NBS research activities.

In the near future the most important activity at the Corona laboratories will be the development of guided missiles. Every phase of missile development will be covered from theoretical and applied research to construction of experimental parts and units. An analogue computer is being set up in the laboratories to be used in flight simulation problems where trajectories of guided missiles must be computed mathematically. The computer, occupying about 1,000 square feet of floor space, can solve problems in minutes that would take trained mathematicians weeks to solve. Some of the existing buildings are being remodeled to house electronic laboratories, the large computer, machine shops, a wind tunnel, cells for testing jet-engines, altitude chambers, a missile assembly section, and a technical library.

Over 200 members of the Missile Development Division of the NBS will move their families to Corona during the next few months. Building materials and credit restrictions have been eased to permit housing construction for the new employees.

Low-Voltage Gas Tube Inverter

J. M. CAGE
MEMBER AIEE

J. C. SCHUDER

TO OBTAIN d-c plate-supply voltages for electronic equipment operated from storage batteries, it is cus- tomary to use either dynamotors or vibrators. Both levices have been used successfully for automobile radio receivers, for example, but engineers have been fascinated for a long time by the possibility of transforming low d-c voltages to higher voltages without mechanical motion.

Since a-c voltages can be transformed and rectified readily, a suitable solution to the problem would be to convert low d-c voltages to a-c voltages of the same order of amplitude. Although the conventional inverter employing gaseous tubes usually is not considered applicable to this problem when the d-c voltage is lower than about 100 volts, experimental gas-tube inverters have been made to function from d-c supplies as low as 6 volts,[1] and the purpose of this article is to study some of the characteristics of a simple inverter with plate-supply voltage lower than the breakdown voltage of the gas-filled tube.

The basic unloaded circuit is shown in Figure 1. The inverter is placed in operation by first closing switch S and then opening it. A typical waveform of the voltage across the capacitor C is shown in Figure 2, and this curve suggests the following description of inverter operation.

At zero time on the curve of Figure 2 the capacitor C has just been discharged through the tube. The tube remains in a conducting state and continues for some appreciable time interval to conduct current I from the supply voltage. It is this rather surprising ability of the tube to conduct current at almost zero voltage drop that accounts for the operation of the inverter. After the interval A, the tube stops conducting and the capacitor starts to charge. The capacitor voltage rises at substantially constant rate, because the inductance has been chosen large, and the stored energy in the inductance causes this capacitor voltage eventually to exceed the supply voltage by a large value. When the capacitor voltage reaches the value V, approximately 13 volts in this case, the tube breaks down and discharges the capacitor in a very short time. The cycle repeats indefinitely.

A necessary condition (but not sufficient, it was found) for sustained oscillations is that the average tube voltage as calculated from Figure 2 equals $6-IR$. This condition is fulfilled only because interval A exists, during which time the voltage remains near zero. Experimentally, this time interval was found to decrease as the supply current was increased. As a hypothesis it is suggested that a large

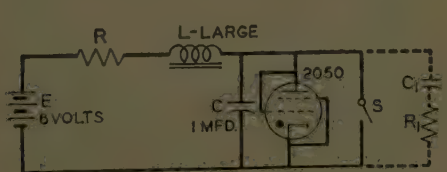
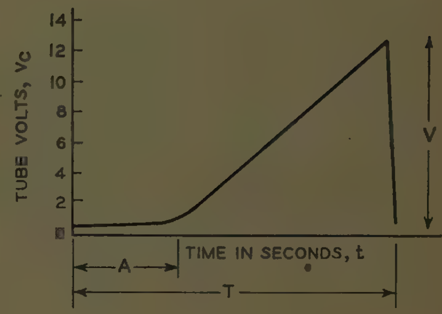


Figure 1. The inverter circuit. The dotted portion shows method of loading

Figure 2. A typical waveform of tube voltage for the unloaded inverter



number of ions remain in the tube following the capacitor discharge. These ions are able to conduct supply current at a very low voltage drop until they disappear. The higher the supply current the faster the ions leave and the shorter time A is.

Further theoretical and experimental investigation of the unloaded inverter circuit of Figure 1 shows that operation is not possible with supply voltages below 4.6 volts. Supply voltages above 4.6 volts give oscillations provided the resistance R is not too large. The value of the capacitor C is not critical, but values below approximately 0.2 microfarad and above 4.0 microfarads will not give sustained oscillations with a 6-volt supply.

Of the several possible methods of loading the inverter, the one shown dotted in Figure 1 was investigated in considerable detail. This method gave a maximum efficiency of 21 per cent. The maximum power output is limited by the average current capabilities of the tube. Theoretical considerations show that this average current rating is probably considerably higher for this type of service than for ordinary use. Using this higher calculated value of average current, a power output of 0.18 watt was obtained.

While the power output for this particular tube and circuit was very low, it very probably could be increased by using a tube with higher current capabilities and certain special characteristics that would enhance the ability to conduct current at nearly zero tube drop after the momentary capacitor discharge. It seems to be indicated that tubes with lower ignition voltages would give higher efficiencies.

It is of interest to note that in this application the problem of inverse tube voltage does not occur.

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This paper is a condensation of an unpublished master's thesis of the same title by J. C. Schuder of Purdue University.

An Improved Telephone Set

A. H. INGLIS W. L. TUFFNELL

The familiar telephone set has undergone numerous changes which will provide better service at lower cost than do present models. Increased transmitting and receiving gain, better sidetone control, broader frequency response, faster dialing, simple ringing control, and a trim appearance are some of the features of the new design

A NEW AND improved telephone set, intended to supplement the present well-known combined set first introduced in 1937, is now being introduced by the Bell system. In view of the established merits of the earlier set, *302* type, of which approximately 25,000,000 are now in use, it is of interest to examine the nature and magnitude of the improvements which justify the effort and expense of such a development, to discuss some of the factors influencing its inception, and to describe the set itself (*500* type) and its characteristics. Before proceeding with this, it is pertinent to define what is meant by an improvement, the nature of the changes involved, and the available means for appraising them.

Improvements may be classified under two general headings. The first includes changes in form and in technical characteristics which make the new design more acceptable in appearance and more convenient to use, and which provide more natural conversation with less effort. The second is that of cost reduction. The changes, no matter how valuable they are in themselves, must be related to their influence on the cost. Ideally, an improvement should provide better service at less cost. Furthermore, an improved telephone set must provide all essential services currently provided and work with the existing plant. In the Bell system the appraisal of a new design is made by a combination of laboratory and field experience using the effect on service as an ultimate criterion.

At the close of World War II a comparison of technical possibilities with service needs indicated that an improved telephone set was possible provided that the design was completely integrated and considered as a unit structure. This meant that the merits of each component would have to be judged by their contribution to the over-all result, and that the design must be suitable for large-scale manufacture at the lowest cost.

Figure 1. External view of the type 500 telephone set

Figure 2. The 500 type set removed from its case

The main general objective was a design which would operate satisfactorily over longer distances from the central office, or with finer gauge and therefore less expensive cable conductors, and to do this with existing central-

Essential text of a conference paper presented at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Recommended by the AIEE Committee on Wire Communications Systems.

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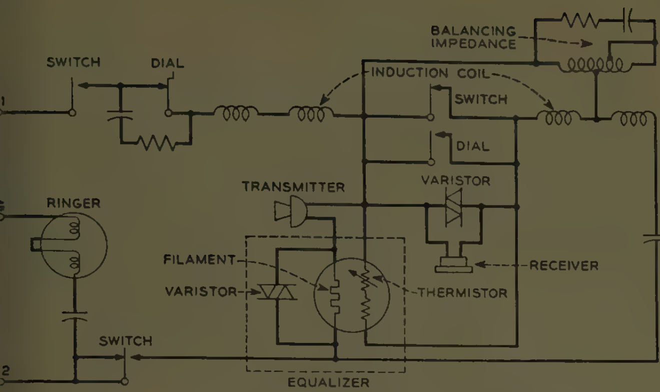

Figure 3. Circuit of the new type telephone receiver

ffice facilities. This meant that a telephone set having n extended range of transmission also must provide corre-ponding increased dialing and ringing ranges.

A second objective was to reduce the difference in ransmitting and receiving levels between the station most listant and that nearest the central office, using one variety of set for individual, party-line, and measured services. With these general objectives in mind, a more detailed lescription of the resulting circuit and design follows.

GENERAL FEATURES

FIGURES 1 and 2 show the new set to be different in form, inside and out, low and sweeping in its lines, nd pleasing to the eye of the great majority of users. On natters of appearance laboratory engineers worked with Mr. Henry Dreyfuss, one of the country's leading exponents of functional design. The handset is smaller, weighing 12 ounces instead of 16 ounces. The dial number plate is external to the periphery of the finger-wheel, where it is more easily seen over wider angles of vision, and is not affected by the inevitable wear of the surface under the ingerwheel. The cords are jacketed with neoprene, grommeted at the handset for longer trouble-free life, and re less subject to twisting. The ringer is provided with manually adjustable volume control which permits the ubscriber to change the loudness over a wide range.

A schematic circuit of the new set is shown in Figure 3. This is a Campbell-type antisidetone circuit similar to the one which has been standard in the Bell system for a long ime, but with improvements added to meet more rigid ransmission requirements.

In general, controls and adjustments for proper service unctioning are reduced or eliminated, and parts are nclosed and protected wherever possible against effects of dirt, moisture, or mechanical damage. Where field eplacement of components is to be anticipated, as in the lial, ringer, handset, and cords, removal and replacement re designed to be easy. Other components are per-manently mounted and are replaceable only in a shop. The dial has no field adjustments and the ringer only one, he bias tension, which is rarely changed. As no parts or wiring are attached to the cover, the set will function with he cover removed. This facilitates both production ssembly and field servicing. During the development tages, many changes important to large-scale manufacture were included as a result of the active participation of the Western Electric Company manufacturing engineers.

The general objective called for transmitting and re-ceiving gains on long loops not exceeding about 5 decibels each because interference, noise, and crosstalk problems would be introduced with larger values; also, improve-ments in quality were desirable. The required trans-mission gains were obtained by new transmitter and re-ceiver designs. Since such volume gains over present levels on long loops would be intolerably loud on short loops, an equalizer was provided to minimize level differ-ences automatically. This is a new element in telephone sets. The initial design (other preferable methods may develop in the future) provides a tungsten ballast filament in series with the transmitter. The resistance of the fila-ment increases with current so that it has little effect on long loops, but on short loops it introduces a battery supply and circuit loss of approximately 5 decibels. This equalizer is shown in Figure 4.

A correspondingly graduated receiving loss is obtained

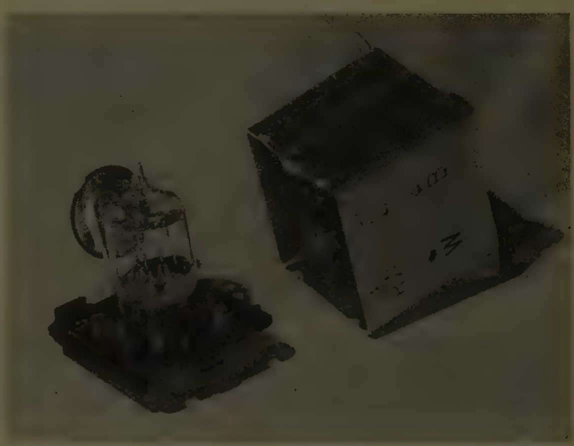

Figure 4. The tungsten ballast filament equalizer

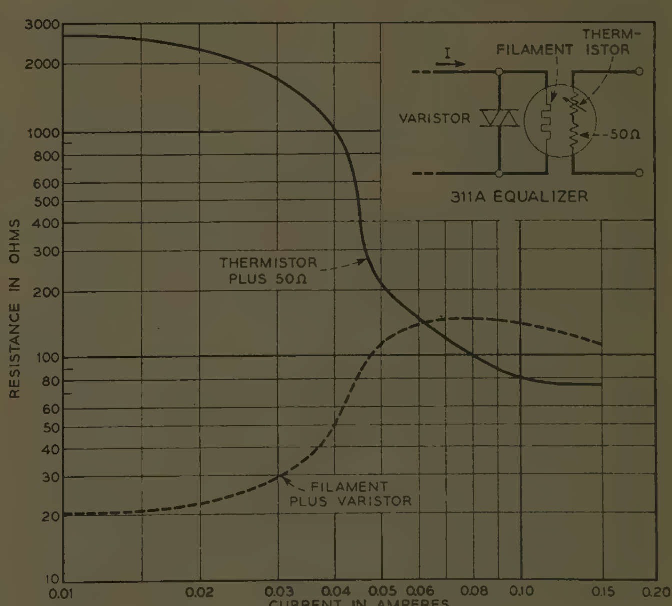

Figure 5. Characteristic of the equalizer circuit in the transmitter

by including a thermistor bead thermally coupled to the tungsten filament in the same structure. This bead, in series with a loss-limiting resistance, is bridged across the receiver. The filament is protected against burnout from abnormal voltages by a bridged silicon-carbide varistor. The resistance-current characteristics of the elements of this equalizer are shown in Figure 5.

One of the principal technical problems was to obtain better control of sidetone. Without this, much of the value of the higher instrument efficiencies would not be realized because of resulting lower acoustic talking levels and an increase of the masking effect on incoming speech of room noise picked up by the transmitter. The solution adopted for the initial design lay in choosing a more complex impedance to give the best over-all balance over the frequency range for the many loop and trunk conditions with which it must function. As a result the new set has essentially the same sidetone as the present set.

Over-all air-to-air frequency responses of the old and new sets are shown in Figure 6 for long and short loops. The broader frequency range and the notable reduction in spread between long and short loop performance are evident. Subsidiary but essential transmission features of the new set include protection against excessively high receiving levels and a filter for the suppression of dialing interference with radio and television reception.

The necessary increase in dialing range was obtained by a new dial design which, by better governing and cam action, controls the degree to which the pulse characteristics vary from the optimum value from dial to dial and from time to time over the period of service.

Acoustic surveys of typical subscriber's premises showed that a ringing signal louder than that of the present station ringer would be desirable. A lower-pitched signal also was indicated as carrying better, particularly for that considerable portion of the population whose hearing has suffered with age. It was known also that an increase in ringing level, if not adjustable at will, would increase the number of maintenance visits to adjust the sound to suit current conditions.

The new ringer apparently meets all these requirements. The easy volume adjustment provided has nearly eliminated requests for readjustment by the maintenance man. This has been done without increasing the cases where the bell cannot be heard and a call is unanswered by restricting the low adjustment point provided to a value which gives nearly as effective a signal as does the present ringer. The ringer, which is more efficient and higher in impedance, permits adequate loop range of operation with greater numbers of connected extensions or party-line stations.

COMPONENT DESIGN

THE HANDSET shown in Figure 7 is smaller, lighter, and easier to use than previous types. As in the case of its predecessor, it is made of phenol plastic. A molded-in cavity through the handle serves as a conduit for the connecting leads to the receiver. Contact with the transmitter terminals is made by means of contact springs supported in a separate plastic cup which serves also as a controlled acoustic cavity for the transmitter and as a necessary acoustic shield between the transmitter and receiver to avoid direct coupling. The components which comprise the handset are shown in Figure 8.

The transmitter unit, while similar in structure to its predecessor, differs in many important details. It is considerably smaller in size and therefore adaptable to the smaller handset. The diaphragm is rigidly clamped at its periphery, thus increasing the output in the upper frequency range as compared to the paper clamped-diaphragm transmitter of previous design. The diaphragm is coupled to an acoustic response-control system consisting of the cavities behind the diaphragm and between the unit and the plastic cup which are interconnected by fabric-covered holes to control the flow of air. In general, the acoustic cavities enhance the response in the

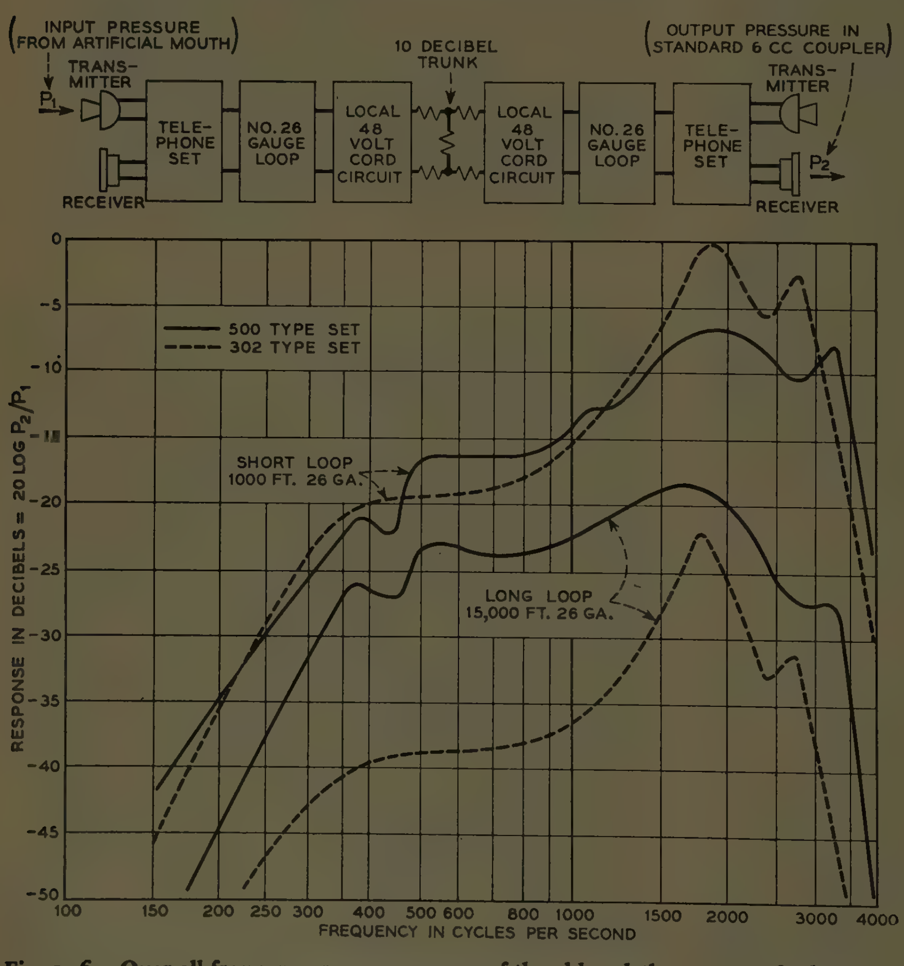

Figure 6. Over-all frequency response curves of the old and the new sets for long and short loops

Figure 7. Cross sectional view of the new handset with the receiver on the left and the transmitter on the right

lower range and the fabric-covered holes act as an impedance to damp out the resonant effect of the clamped diaphragm. The over-all effect is a gradual increase in output with frequency with a broad maximum in the region of 3,000 cycles per second. This, coupled with improved modulation of the carbon and an increase in the effective acoustic pressures by a more advantageous location of the smaller unit with respect to the user's mouth, results in a transmitting gain of approximately 5 decibels.

The receiver unit of the new handset differs radically in design from any previous commercial receiver. It is referred to as a "ring armature" receiver and employs a completely new magnetic and vibratory system. The diaphragm, which in previous receivers has been a simple disc of magnetic alloy, now consists of an annulus of magnetic material (permendur) with a dome-shaped center of phenolic-impregnated fabric material. This magnetic ring armature is supported at its outer edge on a cup of nonmagnetic material which provides the diaphragm seat. The inner edge of the armature is associated in the design with a ring-shaped pole piece which carries the flux from a circular permanent magnet. The use of the composite diaphragm results in a lower mechanical impedance and an appreciable increase in the ratio of effective area to effective mass. This accounts for an improvement in receiving efficiency as compared to the previous handset receiver of approximately 5 decibels, along with an extension of the frequency range. Also, because of the lower mechanical impedance, the loss in intelligibility when it is held off the ear is greatly reduced.

A copper-oxide varistor is incorporated as an integral part of the receiver. In addition to preventing excessively high acoustic levels, this varistor also protects the receiver magnet from possible demagnetizing effects of transient electrical disturbances.

New long-life neoprene-jacketed handset and mounting cords with decreased outside diameter have been developed for use with the new set. In these cords the conductors are not twisted but lie straight and parallel throughout the length of the cord. This facilitates automatic stripping of the jacket and tipping of the cord conductors during manufacture.

The dial mechanism is a complete new development in the interest of improved performance and economy of manufacture. An exploded view is shown in Figure 9. A zinc-alloy frame serves as a base for the various dial

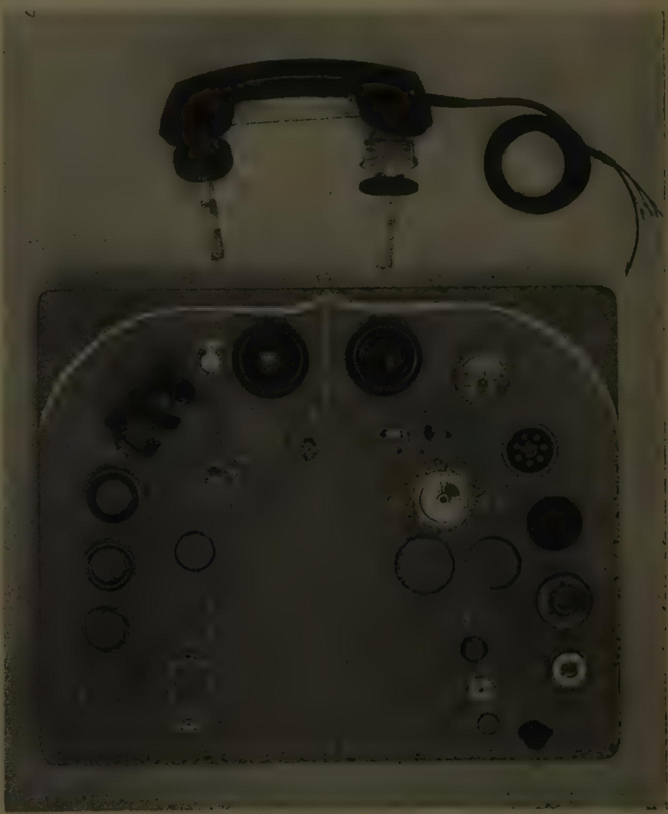

Figure 8. The components of the new type handset

Figure 9. The dial mechanism and its various parts

details and for mounting the dial in the set. A gear-train assembly increases the angular velocity required to operate the pulsing mechanism so that ten pulses may be delivered from somewhat less than one revolution of the finger-wheel and provide the high speed needed for efficient governor operation. The pulsing mechanism consists of a single-lobe cam, a pawl, and two pulsing springs. The pulsing springs, as well as the receiver off-normal springs, are molded in a phenol-plastic block. Closer speed regulation has been obtained primarily by increasing the governor speed and reversing its direction of rotation.

By using a single-lobe cam in contrast to the 10-lobe cam in the former dial, much greater pulse-to-pulse uniformity has been attained. With the 10-lobe cam unavoidable variations in dimensions between lobes are reflected in the pulses.

The new design permits controlling the operating speed to within ± 0.5 pulse per second instead of ± 1 pulse per second as at present. Further, it is confidently expected that this better performance also will apply over the service life of the dial, hence no field adjustment will be necessary.

In the new dial a pair of contacts, operated by a rubber stud on the main gear, close and short-circuit the receiver whenever the fingerwheel is rotated from its normal stopped position. An interval is provided between the last closure of the pulsing contacts and the opening of the receiver short-circuiting contacts. During this time, pulsing transients decay sufficiently so that clicks are not present when the receiver short circuit is removed. The mechanism is protected from dust by a transparent cover.

The ringer shown in Figure 10 uses a single 2-winding coil with a laminated silicon-steel core instead of two coils as in previous type ringers. A small cylindrical magnet of Alnico V provides considerably higher permanent magnet flux.

Increased impedance at ringing and voice frequencies has been accomplished by a magnetic shunt and the physical arrangement of the ringer winding. This permits five ringers per line or between each line wire and ground in place of the usual four.

The sound output has been increased by means of resonators which increase the fundamental gong tones by approximately 18 decibels. In previous ringers, resonators were added only when required. The two gongs differ in their fundamental frequencies by a major third to produce a harmonious sound.

The sound control is a notched wheel which projects through the base of the set and can be shifted to four different positions. This wheel simultaneously controls the armature stroke and clearance between gong and clapper ball so that the force of the clapper striking the gongs changes with each position of the wheel. This provides fairly uniform steps over a range of approximately 14 decibels from the maximum.

The higher static forces in the new ringer require shop adjustments to achieve a proper balance between magnet strength and bias tension. To adjust the ringer manually with conventional methods would have involved prohibitive manufacturing costs. However, through close co-operation between the development and manufacturing organizations, a machine to accomplish this was developed, which on a fully magnetized ringer with an overtensioned bias spring

Figure 10. The ringer which uses one 2-coil winding instead of two coils as in previous ringers

lternately demagnetizes in steps, adjusts the bias spring, nd makes operational tests until the ringer meets its inal requirements.

All components of the network, which comprise the asic telephone-set circuit, the ringing capacitor, and dial ilter, are compactly mounted and wired on a common erminal plate. The assembly is enclosed in a metal conainer filled with a wax compound, the terminal plate orming the cover. In this manner wiring is simplified, he number of terminals is reduced, protective finishes on he individual components are unnecessary, and protection rom mechanical damage is achieved.

A feature of the network is the use of an autotransformer n the sidetone balancing circuit. This element provides nductance and resistance in the balancing circuit and ouples a resistance and capacitor to this circuit at the orrect impedance level. Improved sidetone balance ver the whole range of subscriber loop conditions is acomplished by carefully proportioning these impedance lements.

To permit a simple field conversion for various classes of ervice, a split primary winding is used in the induction oil, and contacts are provided in the mounting switch or closing both sides of the line and for disconnecting the inger when the set is in use where this feature is required.

In previous designs, the weight of the handset was ufficient to operate the switch through a direct linkage cting against the force of the contact springs. This is mpractical in the new set because of the lighter-weight andset. In the new switch, the activating force is a oiled spring and the contact springs are biased to oppose his force. The handset weight, through lever action, has o overcome only the force differential between the coiled pring and the contact springs.

To save space, the ringer and network have been deigned to nest together, the switch mounting accommodates flexible support for mounting one end of the ringer, and he switch requires little space at the base, where space is t a premium, and spreads out at the top where more pace is available. Figure 11 shows this assembly and ts components.

When additional service features are needed, turn button nd exclusion keys and a cold-cathode tube can be added eadily to the basic set assembly. The housing is molded vith a welled section which is easily drilled out to support he stem of a turn-button key. In this manner, the manuacture, on a single assembly line, of a variety of set codes is ossible.

FIELD TRIALS

THE NEW SET was given a comprehensive service trial. This was essential to verify laboratory tests and engieering assumptions. Insofar as practicable, measurements nd observations of such factors as volume levels, dialing ccuracy and speed, answering times, and the number of 'don't answers" were made.

Two separate trials were made. The first involved some 0 preproduction models. These were used first to sample ublic opinion on appearance and performance factors, nd later to provide strictly comparable service experience

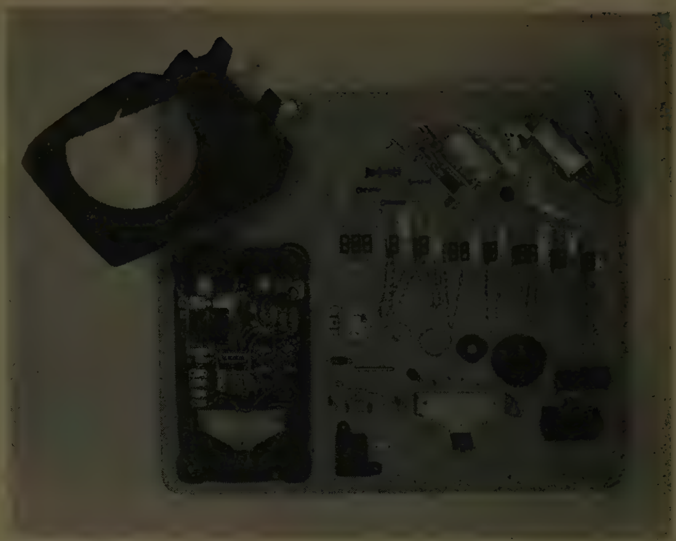

Figure 11. The base assembly of the new telephone

by some 100 selected subscribers, half of whom used new *302* type sets and half new *500* type sets. After some weeks the sets were interchanged between the two groups, so that each subscriber used each type of set. The results of the trial were so favorable that regular production was started.

A more comprehensive comparative trial was started with the first 4,000 production sets in November 1949. Ten locations were chosen covering a range of climatic conditions from New York City in the east to San Francisco in the west, and from St. Paul in the north to New Orleans in the south. Step-by-step, panel, crossbar and private-branch-exchange-connected stations, business and residence, individual and party, measured and flat rate, as well as multiparty rural lines were included. For each *500* type set installed a newly made *302* type set was installed in a comparable location and by the same plant forces.

The field trials showed that all expected functional gains were realized. They provided confirmation of the potential value of the better transmission, dialing, and ringing capabilities of the new set, which can be used either for extension of range of operations from the central office or in increased use of less expensive, finger-gauge cable conductors. The new set, for instance, can be used at most stations where present practice calls for local battery talking sets. Equalization, together with the better dimensional fit of the handset, particularly for women, decreases the range of transmitted levels by decreasing the proportion of low levels without affecting the high. The phase of the trial relating to the relative maintenance effort required for the two types of sets will continue for some time.

The development of the *500* set offers a good example of Bell system's integration of development, manufacturing, and operating experience in the production of apparatus which is of value both to the telephone company and to the public in providing the best telephone service in the most economical manner.

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Piezoelectric Crystals as Sensing Elements of Pressure, Temperature, and Humidity

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Piezoelectric crystals have many properties which make them highly suitable for detecting atmospheric conditions. Some of the techniques for using them are described.

DURING THE past 30 years piezoelectric crystals have found increasing use in engineering applications. This class of materials has been used as frequency stabilizing elements for transmitters and frequency standards, as electromechanical transducers in phonograph pickups and accelerometers, and as elements in wave filters and supersonic delay lines. In these applications care is exercised frequently to prevent the crystal from being affected by atmospheric changes; in many cases hermetic or vacuum sealing and temperature control are employed to insure stability of operation.

Methods of using piezoelectric crystals and associated electronic circuits to detect and measure changes in atmospheric pressure, temperature, and humidity have been investigated. Sensing elements of this type display many desirable properties, particularly for telemetering applications. The output of the sensing element is an electric signal in the form of a frequency or time variation which can be transmitted readily and measured accurately.

MEASUREMENT OF PRESSURE

IN THE measurement of atmospheric pressure two different methods are considered. They are the effect of air pressure on the Q of a low-loss piezoelectric crystal and the change in frequency of a thin quartz oscillating plate produced by differential air loading.

Air Loading Method. Work done by the oscillating crystal against the surrounding atmosphere may be in the form of energy dissipated as acoustic radiation or as viscous damping, depending upon the mode of vibration of this sensing element. The ratio of average stored energy of the crystal to energy dissipated per cycle is a measure of the crystal Q, and varies with the air load against which the crystal works. It is therefore necessary to employ a crystal that has a minimum of loss due to internal friction and damping action contributed by the supports to achieve high sensitivity to air loading. If it is assumed that the crystal frequency and the density of the surrounding atmosphere are such that the usual microscopic equations of motion of the viscous gas are applicable, it can be shown that changes in the crystal Q produced by air loading are inversely proportional to air pressure for crystals vibrating in extension and flexure, and inversely proportional to the square root of pressure for shear mode elements. Experiments and practical considerations indicate that the most satisfactory type of sensing elements for this application are high-frequency quartz crystals vibrating in the thickness shear mode. These crystals, when properly etched and polished and mounted by pressure clamping, may exhibit Q factors of 500,000 or more in vacuum.

A block diagram of an electronic circuit designed for pressure measuring by detecting changes in air loading of the sensing crystal is shown in Figure 1. The sensing crystal is pulsed at regular intervals; its vibrational amplitude is allowed to decay, and the circuit measures a fixed ratio of decay amplitudes. Since the elapsed time between any two amplitudes, a_0 and a, is given by the equation

$$t_1 - t_0 = \frac{2L}{R} \log a_0/a$$

where L and R are the inductance and resistance of the equivalent circuit parameters of the crystal, the elapsed time is also proportional to the Q of the crystal.

A loran timing indicator has been used for measurement of elapsed time between a predetermined crystal amplitude ratio. This timing device serves the additional purpose of generating a 25-cycle square wave voltage for pulsing the sensing crystal. The pulse is supplied to the plate circuit of a sustaining oscillator associated with the pressure sensing crystal.

After the square wave voltage pulse has ended, the crystal decay current flows through the circuit elements in parallel with the crystal. These paralleling elements consist of the input impedance of the vacuum-tube oscillator and all capacitances in parallel with the crystal. The decrement corresponding to the true Q of the crystal is achieved only when the resistance paralleling the crystal is either much greater or less than the reactance of the paralleling capacitance.

The crystal decrement is amplified to approximately 100 volts in the decrement amplifier. The initial amplitude of the decrement is maintained by the action of the charging diode. This voltage is impressed on the grid of a cathode follower and the output at the cathode closely follows the grid voltage.

A matching amplifier, operated at zero grid bias, de-

Essentially full text of paper 51-180, "Piezoelectric Crystals as Sensing Elements of Pressure, Temperature, and Humidity," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Madison, Wis., May 17–19, 1951. Scheduled for publications in AIEE *Transactions*, volume 70, 1951.

E. A. Roberts and Paul Goldsmith are with the Armour Research Foundation, Chicago, Ill.

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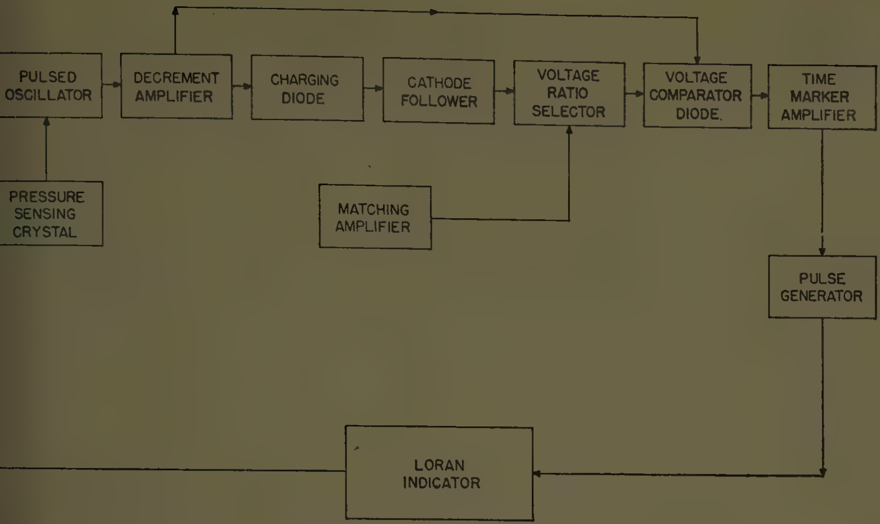


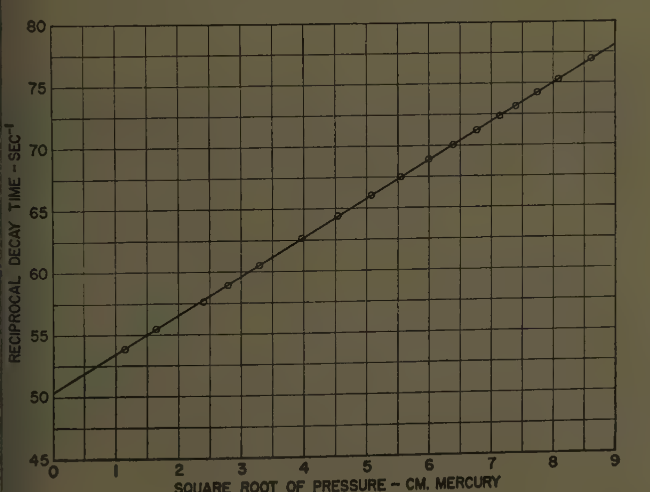
gure 1. **Block diagram of the circuit used for measuring pressure with crystal**

lops a d-c plate voltage that equals the plate voltage of e decrement amplifier when the crystal is allowed to cay completely. This voltage is applied to the cathode sistor of the cathode follower, which therefore has the itial value of decay voltage established at the cathode d and the final decay voltage value at the other.

The ratio of peak voltage at the plate of the decrement nplifier to any point on the cathode resistor is not changed variations in supply voltage or by changes in maximum nplitude of the vibrating crystal. The cathode of the thode follower therefore serves as a voltage ratio selector r which the elapsed time between the selected amplitudes ust be determined accurately.

The function of the voltage comparator diode is to termine the exact time when the crystal amplitude has cayed to the predetermined ratio. When the ratio of cay voltages at the cathode of this diode becomes greater an that selected at the voltage ratio selector, this tube nducts and the steady voltage on the plate decreases ponentially at this time.

The time marker amplifier provides a signal with a steep ading edge to trigger the pulse generator accurately. ne rate of change of voltage at the plate of the voltage



ure 2. **Reciprocal decay time versus square root of pressure**

comparator diode calculated from the time derivative of the decay equation

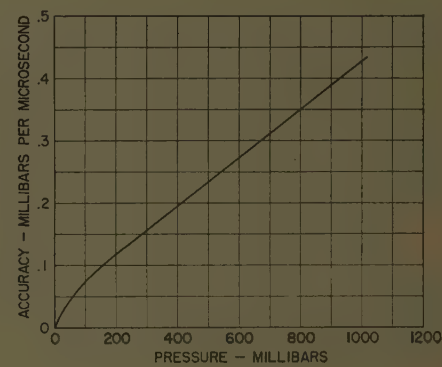
$$a = A_0 e^{-\gamma t}$$

is about $-1{,}800$ volts per second after one time constant for an assumed initial decay voltage of 100 volts and a decay time of 1/50th of a second, the maximum usable timing period on the indicator. The pentode amplifier has a voltage gain of over 100 and, therefore, produces a wavefront with a rise time of 2/10th volt per microsecond.

The pulse generator is a "single shot" multivibrator circuit that produces a positive output pulse, approximately 100 microseconds in duration for each crystal decrement, occurring at the time when the crystal amplitude has decayed to the predetermined ratio selected at the voltage ratio selector.

The time difference between this pulse and the end of

Figure 3. Curve showing accuracy of the pressure measurement



the square wave pulse used to energize the sensing crystal is measured on the timing indicator.

Experimental verification of the relationship between crystal Q and pressure for a shear mode crystal is shown in Figure 2 where the square root of pressure is plotted against the reciprocal of decay time of the pulsed crystal. The pressure-time equation therefore has the form

$$\frac{1}{t} = m\sqrt{P} + b$$

where m and b represent the slope and ordinate axis intercept respectively. Differentiating this equation and eliminating t gives

$$\frac{dP}{dt} = \frac{2\sqrt{P}}{m}(b + m\sqrt{P})^2$$

It is seen that the accuracy of measurement is greatest at low pressures. The measuring accuracy calculated for a high-Q BT-cut 6.4-megacycle thickness-shear crystal is shown as a function of pressure in Figure 3.

Atmospheric variations in temperature and humidity will produce responses in these pressure sensing elements.

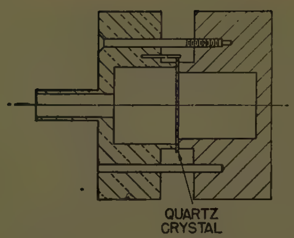


Figure 4. Crystal pressure cup for differential air loading

Since crystal dissipation is a function of the density of the surrounding medium, the necessary corrections for these cross-effects follow the standard relationship between density, temperature, humidity, and pressure for air. An additional temperature cross-effect may result from couplings to spurious modes of vibration. These coupled modes change the internal dissipation of the crystal as a function of temperature. Proper dimensioning of the sensing crystal will minimize this second-order effect.

BENDING OF A CRYSTAL BY AIR PRESSURE

The method of determining pressure by measuring the frequency change produced by the bending of a quartz plate under differential air loading will now be considered. Since the addition of static forces to a linear dynamical system will not change its resonant frequency, this method of sensing pressure does not at first appear promising. A nonlinear elastic theory was developed during the course of this program that accounts for the frequency change that actually occurs when the crystal is bent, and it is shown that this change is proportional to the square of the differential pressure and to the sixth power of the ratio of bending length to thickness.

The sensing crystal for this application is used as a diaphragm over an evacuated cup, as shown in Figure 4. An AT- or BT-cut plated crystal with a low temperature coefficient of frequency may be utilized for pressure sensing. This type of crystal can be clamped at its outer edge without appreciably affecting activity or other performance characteristics. Since the pressure sensitivity of the crystal depends upon the ratio of bending length to crystal thickness, it is important that this ratio is made as high as possible without breaking the crystal from the pressure differential. Experiments have shown that this ratio may be as large as 80 for circularly shaped quartz crystals without exceeding the maximum breaking strain. Frequency changes of 1,400 parts per million per atmosphere can be achieved for these crystals. A typical frequency-pressure characteristic of an AT-cut thickness-shear crystal is shown in Figure 5. It is seen that the characteristic very closely approximates the pressure square law.

The over-all accuracy of pressure measurement possible by this method will now be considered. There must be associated with the sensing crystal a negative resistance source such as a vacuum tube that supplies energy to the crystal to maintain oscillations. While the crystal with its high Q, and consequently steep reactance characteristic, primarily controls the frequency of oscillation, changes in reactance of other circuit components, or changes in voltage or tube characteristics, will affect the frequency of oscillation of the sensing crystal. Temperature changes will produce the most serious frequency change, affecti[ng] both the crystal (since it necessarily has a temperatu[re] coefficient of frequency) and circuit components.

Assuming that the temperature coefficient of the sensi[ng] crystal is known, and a stability of one part per millio[n] can be maintained in the oscillator circuit, it should b[e] possible to determine pressure to an accuracy of 0.7 milli[-] bar with a crystal that changes frequency 1,400 par[ts] per million per atmosphere. Under controlled tempera[-] ture conditions where much greater oscillator stability [is] possible, a considerably greater pressure measuring ac[-] curacy may be achieved. This is apparent from the fa[ct] that oscillator circuits under controlled temperatur[e] conditions may show long-time stabilities of 10^{-8} or bette[r]. The problem of crystal mounting becomes important und[er] these conditions since movement of the crystal in th[e] holder will affect the oscillating frequency. The pressur[e] indicator shown in Figure 6 includes power supply, sensin[g] crystal and associated oscillator circuit, a referenc[e] oscillator, and a mixer to provide an audio frequenc[y] output for pressure indicating.

MEASUREMENT OF TEMPERATURE

An oscillating piezoelectric crystal with a high tem[-] perature coefficient of frequency can be employe[d] for temperature sensing. The temperature coefficient [of] frequency of a vibrating crystal

$$\alpha_f = \frac{1}{f}\frac{df}{dt}$$

is a function of the thermal coefficients of stiffness an[d] expansion. The magnitude of this coefficient of frequenc[y], therefore, depends upon the mode of vibration and th[e] orientation of the crystallographic axis. For quartz th[e] maximum value of the temperature coefficient of frequenc[y] is in the order of 10^{-4} per degree centigrade. This valu[e] is approached in Y-cut plates oscillating in the thicknes[s-] shear mode. As the Y-cut crystal is rotated about th[e] X axis, the temperature coefficient decreases through zer[o] and it is possible to obtain any coefficient between +9[0] and −90 parts per million per degree centigrade b[y] selection of the angle of cut. Crystals designated as A[T]

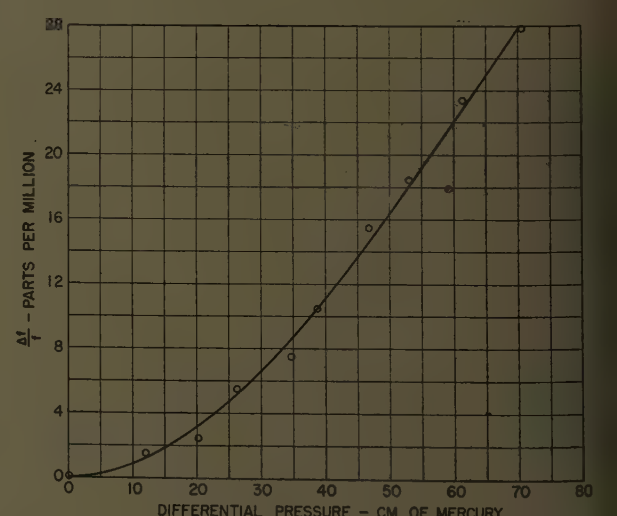


Figure 5. Frequency change due to bending of a quartz cry[stal]

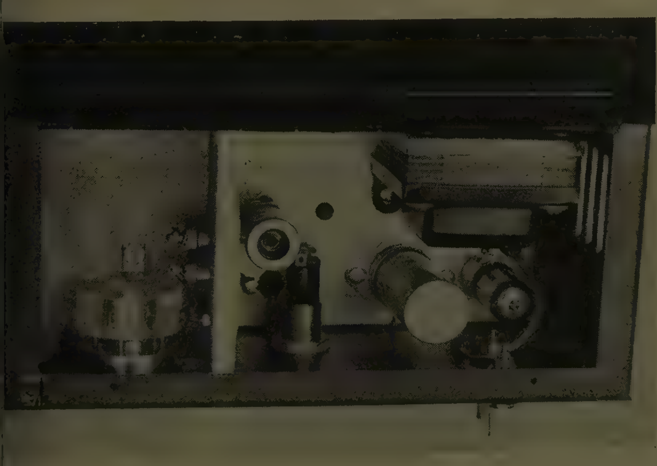
d BT cuts are examples of this type of crystal with the gle of rotation selected to produce a near-zero tempera-re coefficient. Since the coefficient of stiffness is not nstant with temperature, the resulting coefficient of equency is zero at only one temperature for these cuts.

Coupling between the thickness-shear mode and har-onics of lower frequency face shear and flexural vibra-ons are possible since all these modes have different mperature coefficients. The elastic constants responsible r the couplings depend upon the crystal orientation, nd the problem of coupling becomes most serious for ickness-shear elements which have the highest positive mperature coefficients.

Several thickness-shear elements with temperature coeffi-ents ranging from +90 to −80 parts per million per egree centigrade were used in tests to determine their tivity characteristics over a wide temperature range. -cut crystals, while having the highest temperature efficient ($+90\times10^{-6}$ per degree centigrade), exhibited number of frequency discontinuities, while crystals tated 30 degrees or more about the X axis showed satis-ctory frequency spectra over the temperature range from 70 to +60 degrees centigrade. Frequency-temperature aracteristics for two of these crystal cuts are shown in igure 7. The negative temperature coefficients are pical of all thickness-shear crystals rotated more than 35 degrees from the Y cut. While somewhat larger mperature coefficients could be attained by further tation about the X axis, the coupling efficiency to the ystal would be reduced and it would become more fficult to stabilize the associated oscillator circuit.

Thickness-shear crystals rotated through a negative gle about the X axis show variations in temperature efficient similar to those observed for positive angles of tation. These crystals have a higher frequency constant d a lower coupling efficiency for a corresponding tem-erature coefficient.

Temperature coefficients of frequency of face shear artz crystals change with the angle of rotation about the axis in the same fashion as thickness-shear elements. ero temperature coefficients are obtained for this mode −52 and +38 degrees, and the highest temperature efficients occur at +5 and +70 degrees.



igure 6. Top view of an electronic pressure indicator

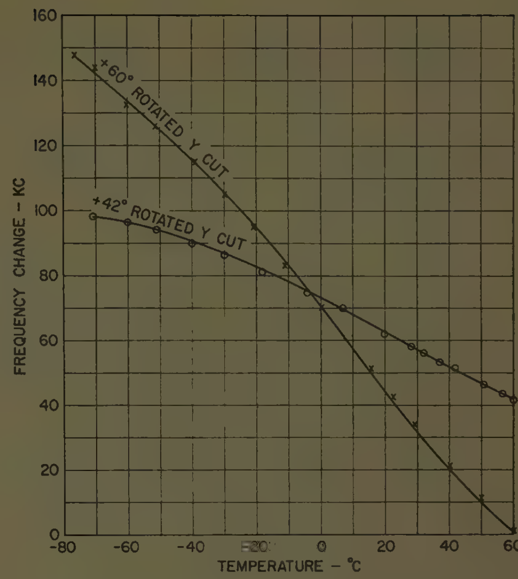


Figure 7. Frequency-temperature characteristics of two 16-megacycle rotated Y-cut crystals. Note the effect of rotation

The accuracy to which the resonant frequency of a crystal may be measured depends upon the frequency stability coefficient of the crystal, the over-all stability of the circuit that sustains it in oscillation, and the accuracy of the associated frequency measuring equipment.

Heat generated in the crystal from vibrational losses must be considered as a possible source of temperature error. Calculations and experiments show that this effect can be made insignificantly small by operating the sensing crystal at a low vibrational amplitude.

Another source of temperature error arises from the effects of solar radiation. The temperature rise in the crystal under certain conditions may cause this sensing element to indicate a temperature that is above the ambient air temperature. Since quartz is very nearly transparent to radiated solar energy, and the necessary electrodes can be applied in the form of highly reflecting surfaces, this type of error, which is inherent in all temperature sensing elements, can be made small for quartz crystals.

Crystal sensing elements can be made very thin and thus reduce thermal lag time. Measurements made on crystals 0.01 centimeter in thickness showed a lag time of approximately 5 seconds in still air and slightly over 2 seconds in air moving at a velocity of 10 feet per second.

Of the synthetic crystals available, ethylene diamine tartrate (EDT) appears to be the most suitable for tempera-ture sensing in view of its high physical and chemical stability under all atmospheric conditions. This crystal has a low mechanical dissipation, contains no water of crystallization, and has good long-time stability charac-teristics. When this crystal is properly orientated it may be made to have a temperature coefficient of nearly −300 parts per million per degree centigrade. Such a crystal with convenient dimensions would oscillate at about 100 kilocycles per second and have a total frequency change of nearly 5,000 cycles over a 150-degree temperature range.

From considerations of the various types and cuts of crystals discussed, it is apparent that several of them are

suitable for temperature sensing. Oscillator circuits similar to those used for measuring pressure by bending of a quartz plate may be used for the temperature sensing crystals and over-all accuracies of better than 0.1 degree centigrade can readily be achieved. The sensitivity of the crystals used in this application exceeds 0.001 degree centigrade.

MEASUREMENT OF HUMIDITY

THE METHOD OF determining humidity with a piezoelectric crystal involves the deposition of moisture on its vibrating surfaces and the use of the resulting change in oscillating characteristics to maintain the crystal at the dew point temperature. Calculations and experiment show that a moisture layer thickness of less than one micron is enough to change significantly the oscillating characteristics of a thin crystal in order that the dew point temperature, and hence humidity, can be determined.

During the course of this research program considerable effort was directed toward the development of control circuits that would maintain the crystal at the dew point temperature. A block diagram representing this general type of circuit is shown in Figure 8. An oscillating crystal is cooled by a cold source which may be dry ice or some other refrigerant and when the dew point is reached moisture begins to condense on its exposed surfaces. The presence of moisture decreases the amplitude of oscillation of the crystal, which in turn produces a signal that causes the heat source to heat the crystal and dissipate the condensate. The source of heat may be a thin resistance element mounted close to the crystal, or it may be heat generated within the crystal produced by a high level of

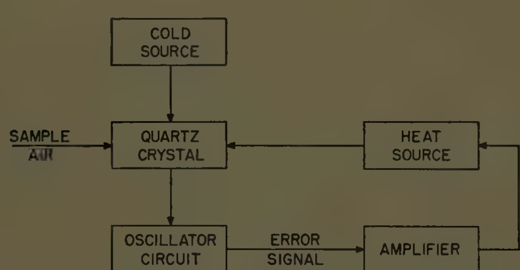


Figure 8. Block diagram of a circuit for indicating dew point

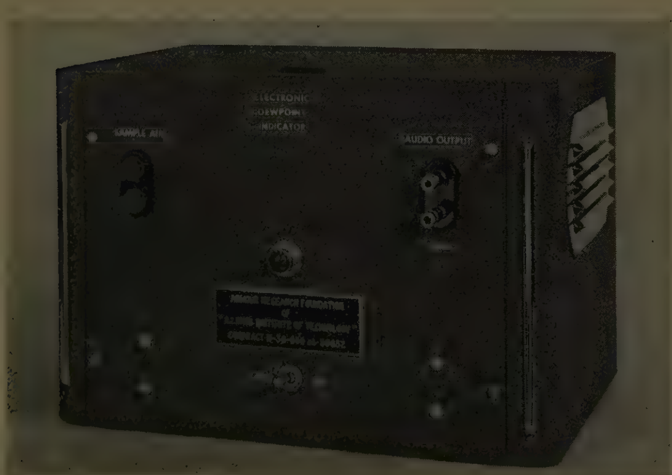


Figure 9. Panel view of the electronic dew point indicator

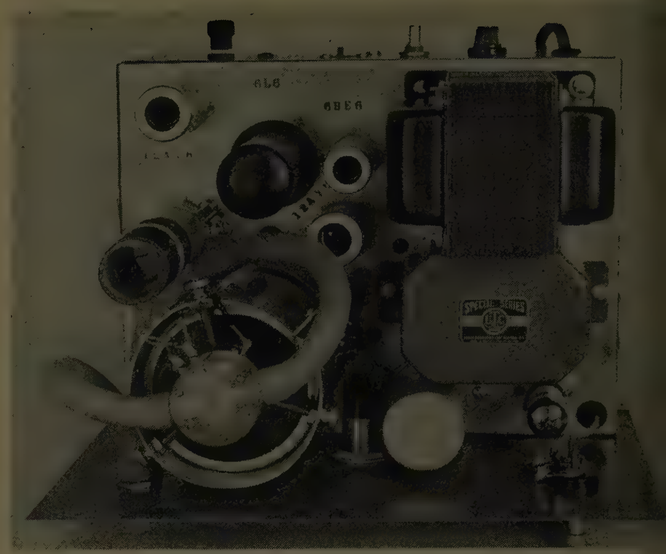


Figure 10. Top view of the electronic dew point indicator

oscillation, or some other source, which is convenien

A dew point indicator using induction heating is show in Figures 9 and 10. This circuit utilizes the induction c eddy currents into the plated surfaces of a pressure-mounte sensing crystal as the method of maintaining the cryst at the dew point temperature. Since both heating an moisture condensation take place on the same surfac the time lag between the appearance of condensate and th corresponding increase in heating is small and stability c operation is achieved readily.

The sensing crystal is placed on one end of a brass tub several inches in length and the other end of the tube i placed in a refrigerant. The induction coil is locate above the sensing crystal. Sample air is passed in throug one side of the crystal holder and out the other side afte passing over the crystal surface.

The sensing element is a pressure-mounted rotate Y-cut crystal with a large temperature coefficient c frequency, and the dew point temperature is determine by measurement of the crystal frequency. The sensin crystal, therefore, performs the functions of humidit sensing and temperature measuring, as well as acting a an integral part of the temperature control circuit.

CONCLUSION

PIEZOELECTRIC crystals used as sensors of atmospheri pressure, temperature, and humidity display man desirable properties. These elements can be made sma in size and light in weight, and are responsive to rapi changes in atmospheric variations. In utilizing the piez electric effect the need of a mechanical linkage to convert meteorologic change to a usable output signal is elim nated. The output is in the form of an electric signa with the intelligence represented by frequency or tim

A further advantage of using elements of this class is th simplicity of detecting and measuring parameter change For example, the humidity crystal, in addition to collectin moisture and indicating its presence by a decrease i vibrational amplitude, serves as its own thermometer t indicate dew point temperature.

The Electrostatic Accelerator as a Source of Ionizing Energy

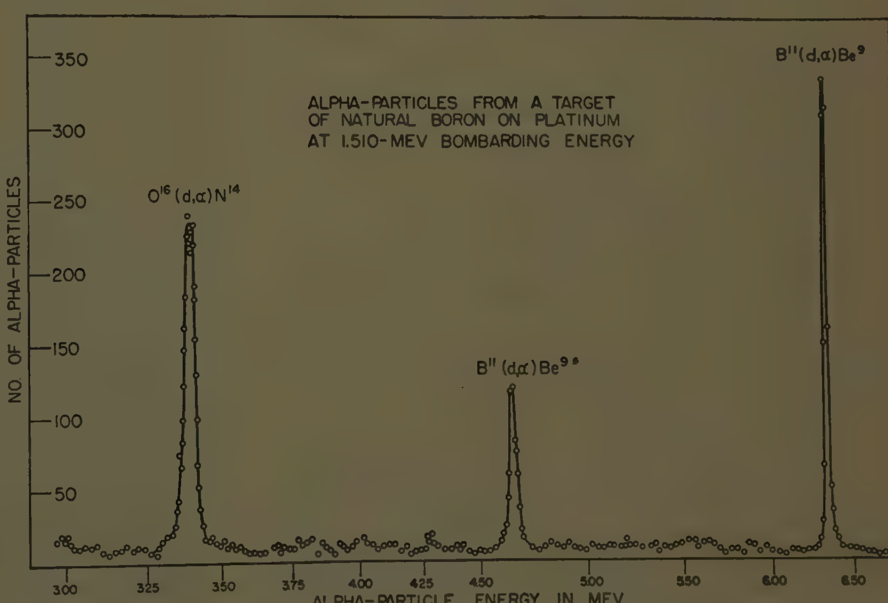
J. G. TRUMP
MEMBER AIEE

The growing need in science and technology for intense sources of high-energy particles and other forms of ionizing energy is being met to an increasing extent by devices which depend on electrostatic forces and principles. Their effectiveness is evident in such diverse activities as nuclear research, supervoltage X-ray treatment of disease, and the sterilization of biologicals and foods.

RUTHERFORD stated the needs of nuclear science in his presi-lential address to the Royal Society in 1928. "I have ong hoped," he said, "for a ource of positive particles nore energetic than those emitted from naturally radio-active substances." The sys-tematic investigation of nu-clear-energy levels and neutron emission thresholds by bombarding elements with streams of protons (Figure 1), deuterons, photons, electrons, and neutrons is now one of the fundamental activities of nuclear physics.

For precision work in this field the impinging particles are preferably nearly monoenergetic and must be continuously controllable over a wide range. For nuclear investigations requiring exceedingly high energies, indirect methods of particle acceleration must be em-ployed as in the cyclotron, betatron, and synchrotron. The binding energies of most nuclei, however, lie in the electro-static accelerator range of a few million and generally below 10,000,000 electron volts, many nuclear resonances appearing at energies less than a few hundred thousand electron volts. Lithium bombarded by protons shows a strong resonance disintegration at the proton energy of 440,000 electron volts where conver-sion occurs into beryllium 8 with the emission of gamma rays. The beryl-lium subsequently disintegrates into two alpha particles. The photo-disintegration of beryllium begins sharply at photon energies of 1,630,000 electron volts and that of deuterium at 2,180,000, these repre-senting the energies by which the ejected neutron had been bound to the residual nucleus. Cross-section studies may be made with neutrons of controlled energy produced by bom-barding selected light ele-ments with electrostatically accelerated protons or deu-terons of appropriate energy. Not only are precise and detailed data on nuclear bind-ing energies and neutron cross sections of great intrinsic value, but such experimental in-formation will some day provide the basis for a more adequate theory to explain the structure of the atomic nucleus.

Because of its inherent capabilities in producing streams of monoenergetic positive ions or electrons and the ease of controlling their energy over a wide range, the Van de Graaff electrostatic accelerator[1] has emerged during the last decade as the indicated instrument for precision nuclear research in the binding-energy range. The principal nuclear research laboratories throughout the world have electrostatic generators actively in use—so far all at energies below 4,000,000 volts. Today at the Atomic Energy Commission laboratory at Los Alamos and at the Massachusetts Institute of Technology (MIT), two Van de Graaff electrostatic accelerators for nuclear re-



Courtesy Dr. W. W Buechner, Physics Department, MIT

Figure 1. Alpha particles emitted in definite energy groups from boron 11 and oxygen 16 bombarded by 1,500,000-volt deuterons from a Van de Graaff accelerator

Essentially full text of paper **51-199**, "Electrostatic Source of Ionizing Energy," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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search aimed at the attainment of 12,000,000 volts are nearing completion.

SUPERVOLTAGE X-RAY THERAPY

An important medical application of ionizing energy lies in the growing recognition of the value of X rays produced at several million volts for the treatment of malignancies. X rays are the penetrating electromagnetic radiation produced by the sudden stopping of high-speed electrons. The effect of increasing the accelerating voltage from the 250,000 volts now in general use for radiation therapy to 2,000,000 volts is to increase the relative penetrating power of the radiation, to reduce its scattering, and to diminish its biological effect in the first layers of tissue at the portal of entry. This last fortuitous fact, the high skin tolerance of supervoltage radiation, is of special value because the skin is an exceedingly radiosensitive organ and often in the past has defined the limit to the dose which could be directed through it toward a deep-seated tumor. X rays produced at 2,000,000 volts appear in a continuous wavelength spectrum which effectively coincides in position with the gamma-ray spectrum of radium in equilibrium with its products. A Van de Graaff X-ray generator operating at 2,000,000 volts produces at the point of electron impact on its water-cooled gold target a source of penetrating electromagnetic radiation physically and biologically identical to the well-studied gamma rays of radium, but with an output intensity greater than that of twice the available world's supply of this precious material.[2] The wise and patient administration of these medically superior rays undoubtedly will advance significantly the clinical results in th eradiation treatment of this difficult disease.[3]

Other sources of supervoltage roentgen rays used for the therapy application are the resonance transformer developed by the General Electric Company and now available in both 1,000,000- and 2,000,000-volt ratings,[4]

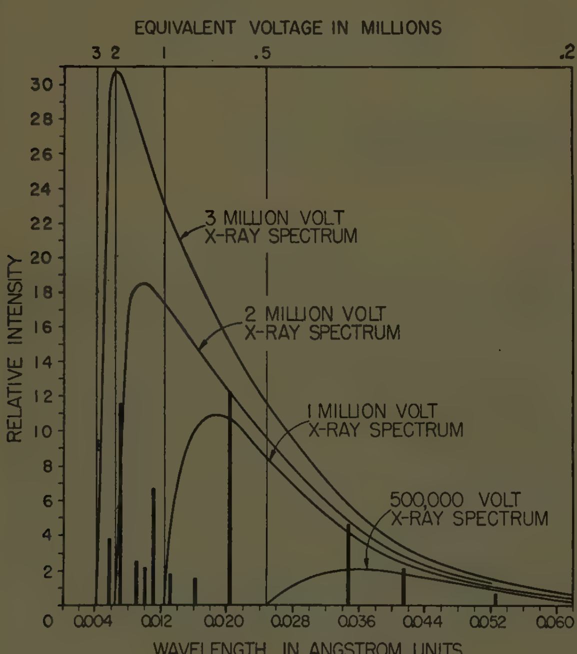


Figure 2. Continuous spectrum of 2.0-, 1.0-, and 0.5-million-volt X rays superimposed in the line spectrum of radium gamma rays

Figure 3. The target end of a 2,000,000-volt electrostatic accelerator arranged for electron sterilization of biologicals

the betatron developed by Dr. D. W. Kerst[5] at the University of Illinois for radiation therapy at 24,000,000 volts, and the microwave linear accelerator[6] developed in England for the production of 4,000,000-volt roentgen rays. All of these devices have features of special interest for the medical application. The electrostatic generator has advantages of simplicity and compactness and produces a copious source of ionizing radiation at suitable energies.

2,000,000-VOLT X RADIOGRAPHY

In industrial radiography X rays produced at several million volts also are finding increasing application. The greater penetrability and freedom from scatter of such rays makes possible the radiography of heavy metal sections with sensitivity and definition fully equal to that obtained on thin sections at lower voltages. Electrostatic generators developed during the war at MIT especially for military radiography produced 2,000,000-volt radiation from a spot on a water-cooled gold target less than 10 mils in diameter.[7] With an electron current of 300 microamperes, steel sections 8 inches thick could be radiographed with an exposure time of 3 minutes, 4-inch steel plate in 6 seconds. Defects of less than 0.5 per cent of the total plate thickness could be readily discerned on the film, complex forgings were found to be readable over a wider thickness range on a single film, and the necessity of packing complex shapes in shot or sand to reduce scatter was eliminated.

An extreme example of the dependence of exposure time on the X-ray voltage was cited in a report of this MIT group. The measured exposure time on a 14-inch-thick steel submarine forging at 2,000,000 volts and 400 microamperes was 4 hours. Calculations based on experimental data indicated that at 1,000,000 volts and with otherwise similar conditions, the exposure time would have been about 12 weeks, while at 500,000 volts the time would have been about 500 years. With 200 milligrams of radium under these conditions, it was computed that an exposure

of about 5 years would be required. On the other hand, a careful calculation for 4,000,000-volt X rays showed that the required exposure would be only about 1 minute.

ELECTRON STERILIZATION

THE STERILIZATION of pharmaceuticals and foods by high-energy electrons is a new field for large amounts of ionizing power.[8] All forms of living organisms, including viruses, bacteria, spores, and molds, are destroyed when traversed by high-energy electrons or their lower-energy secondaries. The biological mechanism involves the excitation and ionization of atoms and molecules of the living organism, the breakdown of omnipresent water molecules into activated hydroxyl radicals, the subsequent chemical change within the organism, and—with a sufficient dose—its resultant demise.[9] This is evidently a new and far more efficient means of sterilizing materials than the age-old technique of heating—a process which raises the energy of vibration of the entire molecule until its thermal disintegration is assured. The most radioresistant organisms, the spore-formers, can be destroyed by a cathode-ray dose of 2,000,000 rep,* an amount of ionizing energy which raises the temperature of the absorber by less than 5 degrees centigrade.[10]

Many types of heat-sensitive pharmaceuticals, such as penicillin, streptomycin, surgical sutures, and adrenal extracts, can be electron-sterilized in their final glass or plastic container without reduction in potency of the material or other adverse effects, Figure 3. More recently there has been evidence that certain living tissues, such as the aorta and other large blood vessels and the bone and marrow, can be given sterilizing doses, if irradiated at reduced temperature, without impairing their effective use as transplants in surgical procedures. It appears that even relatively complex protein molecules, including those of blood plasma and fractions and of many foods, can often be sterilized to advantage particularly if the irradiation is performed at temperatures as low as that of solid carbon dioxide, at which the diminished ionic mobility markedly reduces unwanted side reactions. The shelf life of cheese is limited by the formation of molds which can be destroyed by a relatively low cathode-ray dose penetrating less than 2 millimeters through the wrapper. Wheat, cereals, meats, and other food materials may be sterilized advantageously by this method.

The Van de Graaff electrostatic accelerator has proved to be a valuable source of cathode rays of high energy for the scientific research prerequisite to such applications and is now being designed for routine production sterilization of large quantities of materials. Compact cathode-ray units developing 250 microamperes of 2,000,000-volt electrons are now available for fundamental radiobiology, for the research investigation of cathode-ray effects and techniques covering a diversified program, and for routine production sterilization. A unit of this rating, for example, is capable of handling the entire surgical suture sterilization of a large manufacturer. In food applications, however, far larger amounts of ionizing energy are generally required. A basic machine for such purposes is now under construction rated at 3,000,000 volts and 4 milliamperes of electron current, capable of delivering 12 kw of ionizing power in the form of a high-energy electron stream rapidly scanning a product-laden belt.

* A rep is that amount of ionizing radiation, whether X rays, cathode rays, or neutrons, which results in an energy absorption of 93 ergs per gram of water or equivalent material.

VAN DE GRAAFF OPERATING PRINCIPLES

THE VAN DE GRAAFF electrostatic accelerator[11] is essentially a belt conveyor of electric charge designed for the attainment of high constant potentials and provided with a suitably evacuated tube for the acceleration of charged particles. As indicated in Figure 4, electric charge is sprayed onto a moving belt of high dielectric strength and carried into the field-free space of a well-rounded metallic terminal. This high-voltage terminal is supported from ground by an insulating column constructed of spaced metallic equipotential members and glass disk insulators. Both the charge-conveyor belt and acceleration tube are mounted within this column, along which a uniform voltage distribution is secured by the flow of charge from terminal to ground through resistors between the metal sections. Charged particles originating in the terminal end of the tube are progressively accelerated and focused by a succession of electrodes which produce a uniform electric field along the tube. These electrodes obtain their potential by connection to corresponding equipotential planes in the insulating column of the generator.

The steady constant potential of the terminal is maintained by balance between the controllable current brought to the high-voltage terminal by the belt, the voltage distribution current down the generator column, and the current accelerated along the vacuum tube. The generator voltage may be brought to any equilibrium value by regulating the charge sprayed onto the belt. It is common

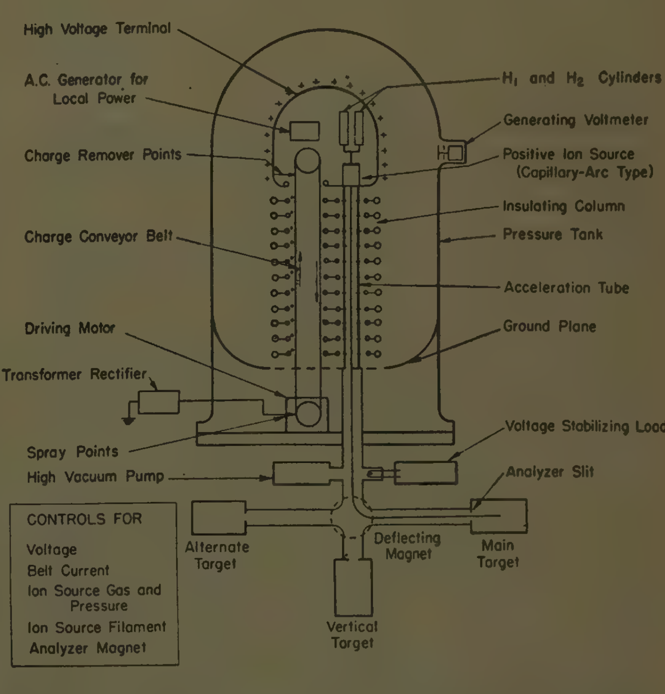


Figure 4. Functional diagram of a Van de Graaff positive-ion accelerator

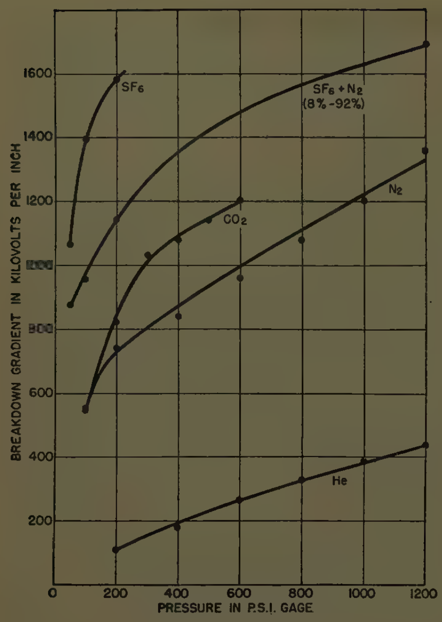


Figure 5. Relative breakdown strength of various gases as a function of pressure up to 80 atmospheres. Uniform field, constant potentials, 0.5-inch gap, polished stainless steel electrodes 6 inches in diameter

practice to utilize both ascending and descending runs of the belt of an electrostatic generator by causing them to carry charges of opposite polarity.

The current rating of a belt-type electrostatic generator is independent of terminal voltage and depends directly on the area per second of insulating surface entering and leaving the terminal and on the dielectric strength of the gaseous medium in which it is immersed. It can readily be shown that the maximum charge density on a surface in atmospheric air is 5.3×10^{-9} coulomb per square centimeter, assuming 30 kv per centimeter gradient and a uniform electric field normal to the surface in both directions. In practice, about half this charge density can be realized. Thus about 4×10^5 square centimeters per second of belt surface entering or leaving the terminal are required for each milliampere of current. Consideration of Gauss's law shows that, unless electrically shielded from each other, adjacent runs of belt must run in opposite directions and carry charge of the opposite sign.

In all direct acceleration apparatus operating above 500,000 volts the charged particles are accelerated in successive increments by fields produced between a series of metal diaphragms spaced between the annular glass sections of the evacuated tube. The particles pass through axial holes in these diaphragms, which serve in part to shield the inner glass surfaces from bombardment of scattered particles and also to maintain a well-focused beam through the focusing action of the slightly fringing electric fields. By this arrangement the cathode and anode ends of the tube may be separated by distances sufficient to insure the insulation of the total terminal voltage, and the insulation problem is reduced to that of a series of relatively low voltage gaps in high vacuum. Only in the limited axial region lengthwise the tube through which the accelerating stream of particles must pass does the possibility of total voltage breakdown in vacuum arise.[12] Nevertheless, it is common experience that the insulating length of direct acceleration tubes must increase more rapidly than their voltages. The best performance today permits the reliable insulation and acceleration of particles to 2,000,000 volts in a tube whose insulating length is 33 inches, and the attainment of 6,000,000-volt particles in an insulating length of 12 feet.

Since the particles reaching the grounded end of the tube have been accelerated by a constant potential, they become available as a well-directed stream arriving continuously in time and closely homogeneous in energy. The smooth controllability of this energy over a wide range, together with this homogeneity, is a principal advantage of the Van de Graaff electrostatic accelerator for purposes of scientific research. In a cathode-ray accelerator the high-voltage terminal is charged negatively, and the source of electrons within the acceleration tube is a heated tungsten filament. The high-energy electrons finally pass into the atmosphere through an aluminum window of a few mils thickness, which they traverse with little loss of energy or scattering. Such an electron stream will then continue on through the air and be directly incident upon the biological material or substance to be sterilized. On the other hand, the high-energy electron stream may be caused to impinge upon a water-cooled target of high-atomic-number material, such as tungsten or gold, in which case its kinetic energy is converted in part into penetrating electromagnetic radiation. These rays proceed outward in all directions, though with increasing preference for the forward direction at higher voltages. This X-ray source may be defined into a beam by absorbing the unwanted radiation in lead. The substitution of a source of positive ions—a low-voltage d-c discharge in low-pressure hydrogen from which the ions are extracted through a tiny orifice by a probe voltage—for the electron source and the operation of the generator at positive potential transforms it into an instrument for precision nuclear research.

ELECTROSTATICS VERSUS ELECTROMAGNETICS

ELECTROSTATIC PROCESSES are inherently more efficient in the production of high constant potentials than electromagnetic methods. The maintenance of an electric potential requires merely the presence of electric charge, and is described by the relation $V=Q/C$, where V is the terminal potential, Q is its isolated charge, and C its

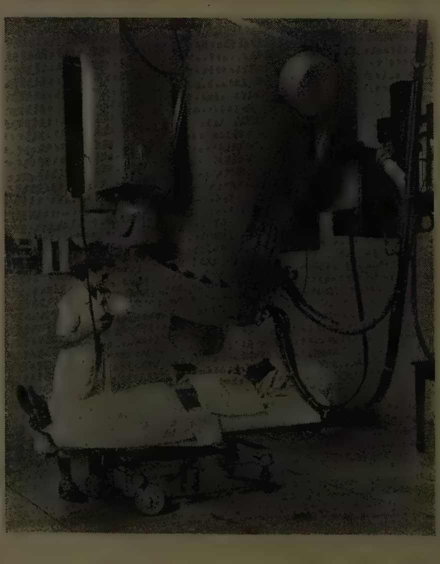
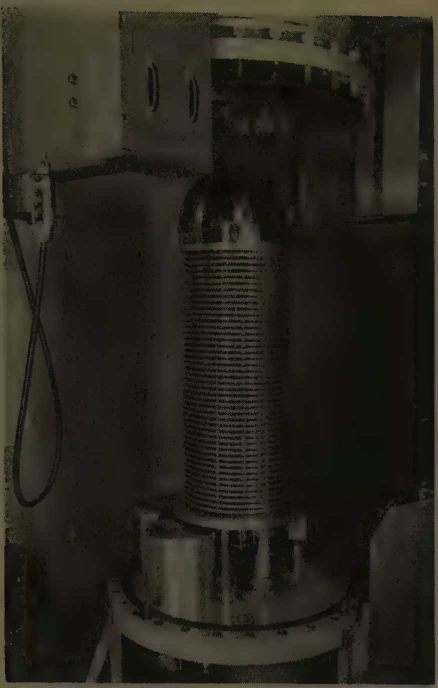


Figure 6. A 2,000,000-volt Van de Graaff X-ray source used for deep tumor therapy at the Sheffield National Centre for Radiotherapy in England

Figure 7. A 2,000,000-volt electrostatic generator with tank removed to show the high-voltage terminal and the 33-inch insulating column



capacitance to ground. This equation implies that the attainment of constant potentials of several million volts is primarily an insulation problem and that the terminal and its supporting column should be designed so as to exploit the most advantageous electric field configuration and insulating materials. In an electrostatic belt generator the superior voltage-insulating properties of gases at high pressure and of certain electronegative gas molecules can be fully utilized to reduce the physical size of the terminal and gap for a given voltage, at the same time increasing the charge-carrying capacity of the belt.

In electromagnetic equipment the attainment of high alternating voltages inevitably involves the continued and cyclical flow of electric charge and the development of large amounts of reactive power. Merely to charge the simple high-voltage terminal of the 2,000,000-volt Van de Graaff accelerator shown in Figure 7 to the same peak value by 60-cycle electromagnetic means would require over 30 kva of reactive power. In the ingenious resonance transformer this reactive power is avoided, as far as the external circuit is concerned, by an air-core transformer design in which an exact balance is achieved between the inductive and capacitive power at 180 cycles per second or higher frequencies. The large internal power circulating between the electric and magnetic fields and the dependence of peak voltage upon considerations of flux and coil ratios tend to limit the advantage attainable with better gaseous insulation in such a-c electromagnetic apparatus. The conversion of a-c power to high constant potential by any of several ingenious circuit arrangements invariably requires a series of electronic rectifiers, filament sources, and capacitors—all of which constitute a formidable technical difficulty.[13]

COMPRESSED-GAS INSULATION

The use of gases at high pressure is now an essential feature of compact electrostatic accelerators. By the principle of similarity, a k-fold increase in the dielectric strength of the gas surrounding an electrode system permits a k-fold reduction of all of its physical dimensions without changing its voltage-insulating ability. In the limit the volume occupied by high-voltage electrostatic apparatus varies inversely as the cube of the dielectric strength of its gaseous insulation. These considerations have encouraged research in the field of compressed-gas dielectrics and have led to the use both of progressively higher pressures and of electronegative gas molecules for the insulation of high-voltage devices.

Figure 5 shows the relative dielectric strength of such dissimilar gases as helium, nitrogen, carbon dioxide, and sulfur hexafluoride over a pressure range from 1 to 80 atmospheres and with total applied voltages up to 1,200,000. The gaseous gradients can be observed to be substantially higher than those permitted by typical solid and liquid materials. The curves show the value of electronegative molecules containing oxygen and fluorine in extracting energy from free electrons in the gap and in converting these prolific ionizing agents into innocuous negative ions by attachment. These characteristics of electronegative gases have been recognized in principle since the investigations of Natterer, Paschen, and others at the end of the last century.[14] Two gases, Freon 12 (CCl_2F_2) and sulfur hexafluoride (SF_6), have now emerged as the most practical gases of this character. Both have nearly three times the dielectric strength of nitrogen at the same pressure in a uniform field. At room temperature Freon 12 saturates at about 5 atmospheres of pressure, while sulfur hexafluoride allows over 30 atmospheres. Both show high chemical stability, but dissociate under the influence of corona and spark-over.[15]

2,000,000-VOLT ELECTROSTATIC ACCELERATORS

A powerful source of ionizing radiation which has attained compactness and simplicity through the use of compressed gaseous dielectrics and good electrostatic design is the 2,000,000-volt Van de Graaff accelerator manufactured by the High Voltage Engineering Corporation. This instrument in various forms is used for the production of X rays for medical therapy and industrial radiography, of streams of electrons for biological studies and the sterilization of materials, or of positive ions for nuclear research (Figure 6). Its high-voltage terminal is a hemispherical stainless steel shell 15 inches in diameter, supported on an insulating column of 33-inch active length. This column is built up of metallic equipotential planes separated by glass insulators, and the terminal voltage is divided uniformly along the column by means of high-value resistors. The charge-conveyor belt is 6 inches wide of multi-ply rubber fabric and travels about 4,000 feet per minute. The acceleration tube is also mounted within the column adjacent to the belt and is likewise divided into over 40 sections by aluminum diaphragms, each of which acquires its proper potential by direct connection to the column. The target end of the acceleration tube extends through the base plate of the pressure tank and terminates in a water-cooled gold target for the production of X rays or an aluminum window when high-energy cathode rays are desired. The entire

electrostatic source and acceleration tube is contained within a grounded steel tank 36 inches in diameter and less than 6 feet in over-all length filled with a mixture of nitrogen and carbon dioxide at 27 atmospheres of pressure. See Figure 7.

Since the efficiency of X-ray production is low, maximum output ionizing power from an electrostatic accelerator is realized when the high-energy electrons are permitted to emerge into the atmosphere for direct use as cathode rays. In this case the output power is equal simply to the product of electron current and voltage and is 500 watts in the cited example. The total power input is 2,500 watts, and the over-all efficiency is 20 per cent, a figure higher than that attainable by any other method.

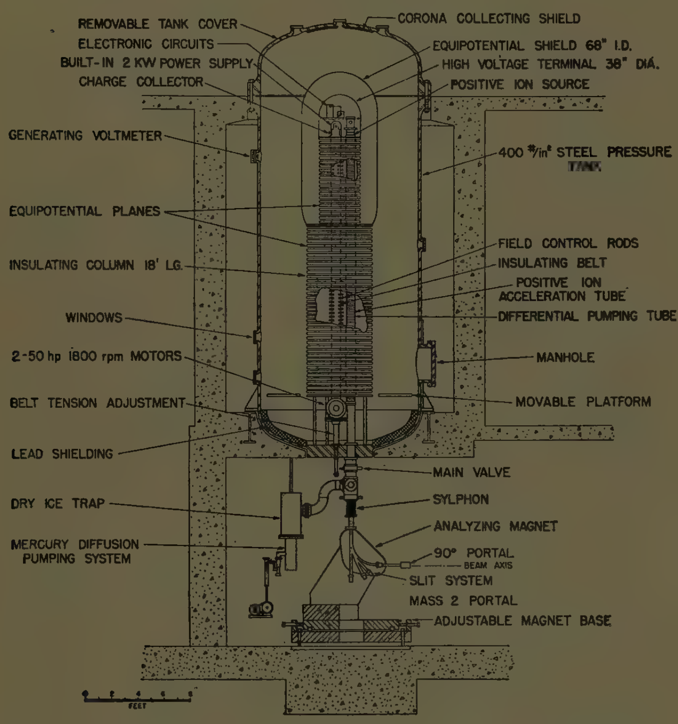


Figure 8. Diagram of the 12,000,000-volt electrostatic accelerator now nearing completion at MIT

Most of the input power is used in overcoming the windage arising from the motion of the belt through the compressed gases. Lesser amounts go into belt flexure, pulley bearing losses, column resistor current, and corona spray power.

Five hundred watts of electron energy at 2,000,000 volts is capable of profound biological and photochemical activity. This amount of ionizing energy can deliver 1,000,000 rep to over 300 pounds of material per hour and is capable of sterilizing production amounts of pharmaceutical materials on an economic basis. When the electron energy is converted into penetrating X rays by impinging upon a target of high atomic number, even though the efficiency of conversion is only slightly more than 5 per cent at this voltage, the subsequent electromagnetic emission in the continuous X-ray beam corresponds to that of over 5,000 grams of radium.

12,000,000-VOLT POSITIVE-ION ACCELERATOR

THE HIGHEST-ENERGY apparatus so far attempted by the electrostatic method are the 12,000,000-volt positive-ion accelerators now under construction at MIT and Los Alamos. The MIT unit, which is illustrated in Figure 8, is to be housed in a vertical steel tank 12 feet in diameter and 32 feet high designed for gas pressures up to 27 atmospheres. The tank is mounted within a concrete silo which forms a part of the special laboratory building, an important feature of which is the large radiation room 40 feet by 60 feet by 16 feet surrounded by 2-foot-thick concrete walls.

The terminal of this electrostatic accelerator is 38 inches in diameter mounted on an insulating column 18 feet high. A 20-inch-wide belt traveling 3,600 feet per minute will supply over 1 milliampere of current to the terminal when required. There are two parallel acceleration tubes within the column, one provided with a positive-ion source in the form of a low-voltage hydrogen arc and the other with an electron source consisting of a spiral tungsten filament. In addition to protons, deuterons, and alpha particles, the accelerator is thus available also as a source of high-energy electrons, X rays, and—through the intermediate process of bombarding light elements—of neutrons.

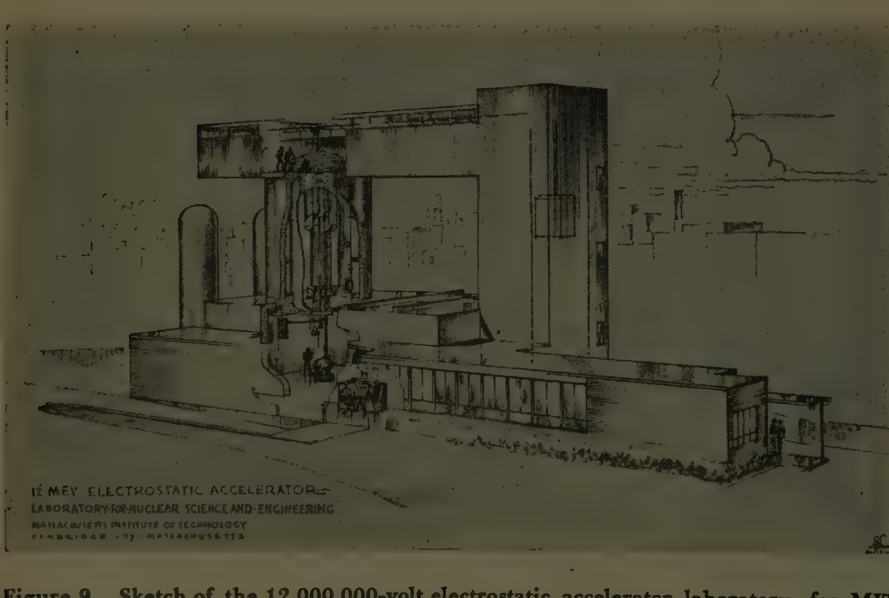


Figure 9. Sketch of the 12,000,000-volt electrostatic accelerator laboratory for MIT

At a position between the high voltage terminal and the grounded steel tank an equipotential shield of stainless steel is provided. This shield is mounted on the insulating column at a region one-third its total length from the terminal and therefore would be maintained at 8,000,000 volts for the maximum terminal voltage of 12,000,000. The effect of such an equipotential shield is to redistribute the electric field intensity in the air gap between terminal and tank and thus permit the attainment of higher total voltages. The Los Alamos design has many interesting points of difference when compared with

that of MIT, an important one being the use of five such intermediate equipotential shields arranged for a nearly uniform gradient from terminal to tank.

FUTURE TRENDS

IMPORTANT ENGINEERING improvements are in progress directed toward increasing the operating voltage, current capacity, and compactness of this electrostatic instrument. Electronegative gases will undoubtedly find an important place in units designed for extreme compactness. The elimination of corona-charging and charge-removing processes in favor of conduction-charging of the belt is receiving attention, particularly since this avoids the fundamental conflict of a superior gaseous dielectric which must still at certain points be capable of good conductivity through ionization. Fundamental and engineering studies of the factors upon which depend the voltage-insulating ability of high vacuum are most essential since the capabilities of the acceleration tubes are still the primary design limitation in modern Van de Graaff accelerators. Electronic voltage stabilization now practiced at most research institutions will probably become standard equipment on therapy and radiographic units. In particular, for the sterilization of large amounts of material, attention will be given to the attainment of the maximum charge-conveying capacity of the belt surfaces.

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Measurement of D-C Machine Parameters

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An equivalent circuit is suggested to represent the d-c machine when operating under near normal current conditions; and circuits and techniques for obtaining the constants of the circuit are described.

PARAMETER measurement methods that are used for d-c machines have been of considerable interest of late because of the necessity of predicting short-circuit characteristics and applications to servomechanism circuits. A d-c machine short circuit involves extremely large armature currents while servo circuits involve currents of a much smaller magnitude. It is with the latter problem that this article is mainly concerned. While the currents are of more or less normal magnitudes in servo circuits, these currents may change sufficiently rapidly so that the inductive effects in the machine must be considered along with the resistances and other factors; in other cases the rates of change of currents may be sufficiently low so that the inductive effects can be ignored. The standards do not cover the inductance measurement problem, and further, the methods of determining the resistances prescribed by the standards are based on giving values accurate enough for efficiency data but do not result in accurate results in

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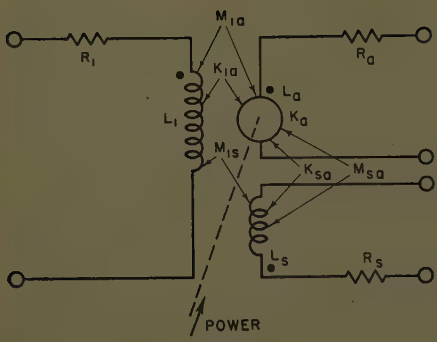


Figure 1. Equivalent circuit for the compound dynamo

servo system calculations. The author has had some success in the use of a d-c machine equivalent circuit for servo system analysis and has developed a means of measuring the parameters of this equivalent circuit by means of certain d-c plus power-frequency a-c measurements. It is the purpose of this article to present this equivalent circuit and to discuss the measurement of the parameters of the circuit by various means; experimental verification will be presented.

In this approach, it is assumed that the observer has no knowledge of the machine design information and is more or less approaching the machine as a "black box" problem. In general, the usual d-c machine may be considered as a 6-terminal network in which there are resistances, self-inductances, mutual effects between the fields and armature circuits, and speed-induced voltages. Because the general features of the d-c machine are known, one may set down an equivalent circuit without resorting to the generalized 6-terminal network analysis. Undoubtedly Miller's equivalent circuit[1] was formulated by others at an earlier date (1933), but his is the first notation that has come to the author's attention; others[2,3] have used this circuit. Figure 1 shows this equivalent circuit. The shunt field has a certain resistance and self-inductance, R_1 and L_1. The shunt field also will induce a transformer-type voltage in the armature circuit to which it is inductively coupled through brush shift, or demagnetizing effect of armature reaction, all these inductive effects being summarized as a mutual inductance, M_{1a}; in addition, there is also a transformer-induced voltage present in the series field due to the mutual inductance, M_{1s}. The shunt field will induce a speed-generated voltage at the brushes due to the rotation of the armature; this speed-induced voltage constant is designated by K_{1a} ohms per revolution (induced volts per ampere of field current per unit speed). Similar constants, R_s, L_s, M_{sa}, M_{1s}, and K_{sa}, will be associated with the series field and be defined similarly.

Any other windings in the same magnetic circuit as the shunt field will have similar constants. Considering now the armature circuit, it will have a resistance, R_a, which represents the resistance of the armature conductors, brushes, and interpoles; and a total self-inductance, L_a, corresponding to the same circuit elements. The armature circuit is loosely coupled to the shunt field through M_{1a} and to the series field through M_{sa}. It will also self-generate a speed voltage at the brushes due to current in the armature alone, the constant describing this voltage defined as K_a. It is with the determination of the constants R_1, R_s, R_a, L_1, L_a, L_s, M_{1a}, M_{sa}, M_{1s}, K_{sa}, K_{1a}, and K_a that this article is concerned.

There are three approaches to the solution of this problem that have been reported to date, (1) the transient method basically presented by Bower[4] in his paper on Amplidyne characteristics, (2) the bridge method presented by Koenig,[5] and (3) the a-c method discussed very briefly by the author in a previous paper[3] and by Snively and Robinson.[6] The bridge method has been well expostulated, but neither the transient nor the a-c methods have been applied to the whole d-c machine. Thus. this article will be confined to the applications of Bower's work to all d-c machines and to an amplification of the a-c techniques which the author has employed and which Snively and Robinson have used to determine the armature self-inductance.

NOMENCLATURE

K_a = armature self-induced speed-voltage constant, ohms per rpm
K_{sa} = series field to armature speed-voltage constant, ohms per rpm
K_{1a} = shunt field to armature speed-voltage constant, ohms per rpm
L_a = self-inductance of armature circuit, henrys
L_s = self-inductance of series field, henrys
L_1 = self-inductance of shunt field, henrys
L_2 = self-inductance of combined series field and armature circuit, henrys
M_{sa} = mutual inductance between series field and armature, henrys
M_{1a} = mutual inductance between shunt field and armature, henrys
M_{1s} = mutual inductance between shunt and series fields, henrys
M_{12} = mutual inductance between shunt and series fields and armature, henrys
N_1 = shunt field turns
N_s = series field turns
R_a = resistance of armature circuit, ohms
R_s = resistance of series field, ohms
R_1 = resistance of shunt field, ohms
ω = speed, rpm

All quantities except the self- and mutual inductances may be measured by certain d-c tests. The field-winding

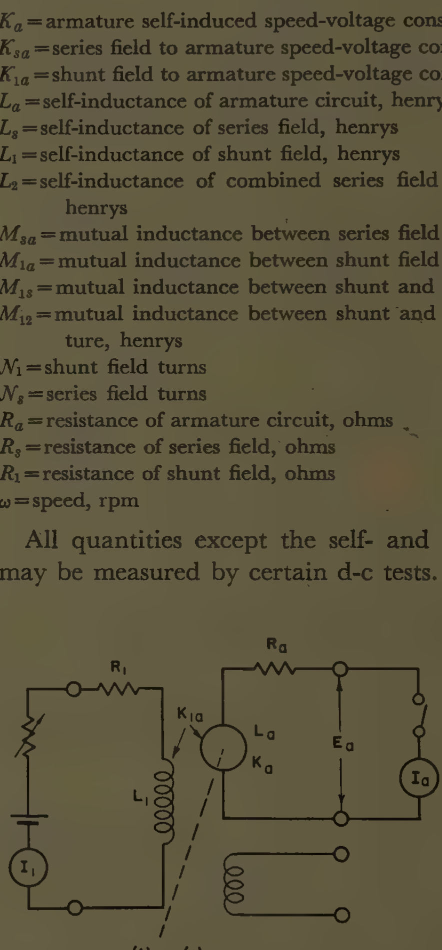


Figure 2(A). Test circuit for finding d-c machine constants. I_1 is varied, and values of E_a and I_a are read for two different speeds

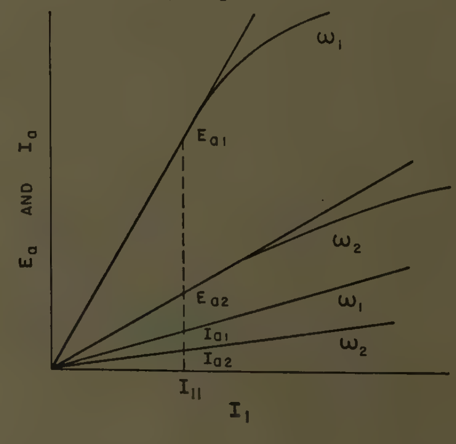
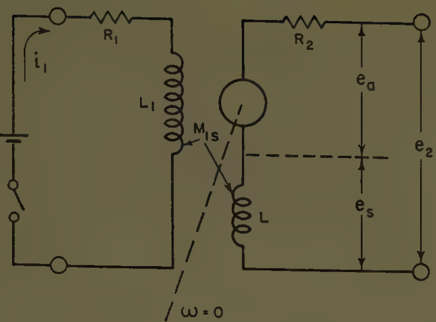
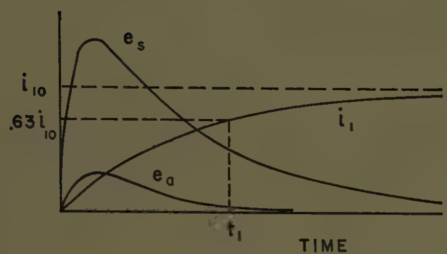


Figure 2(B). Curves resulting from the data collected from the circuit of Figure 2(A)



igure 3(A). Tran- ient method for neasuring shunt ield self-inductance nd series field nutual inductance



'igure 3(B). Oscil- ogram resulting rom closing the witch in Figure 3(A)

esistances may be measured by means of voltmeter-mmeter, Wheatstone, or Kelvin Bridge methods. The esistance of the armature and the other constants can be btained by means of the open- and short-circuit tests as d-c generator, a test somewhat synonymous to the syn-hronous impedance test for alternators. Figure 2*A* hows the manner of conducting the tests. Curves of pen-circuit voltage and short-circuit current as a function f shunt field current for two different speeds, ω_1 and ω_2, re found and plotted as shown in Figure 2*B*. This test hould be confined to the lower portion of the saturation urve where the cross-magnetization due to armature eaction does not introduce a net demagnetization of the oles. If this is done, the curves will be nearly straight ines over the lower portion. In Figure 2*B*, at the field urrent, I_{11}, and at the speed ω_1

$$\frac{E_{a1}}{I_{a1}} = R_a + K_a\omega_1$$

t the same field current but at a speed of ω_2

$$\frac{E_{a2}}{I_{a2}} = R_a + K_a\omega_2$$

rom which

$$R_a = \frac{1}{\omega_2 - \omega_1}\left(\omega_2\frac{E_{a1}}{I_{a1}} - \omega_1\frac{E_{a2}}{I_{a2}}\right)$$

$$K_a = \frac{1}{\omega_2 - \omega_1}\left(\frac{E_{a2}}{I_{a2}} - \frac{E_{a1}}{I_{a1}}\right)$$

The constants K_{1a} and K_{sa} are the slopes of the open-ircuit saturation curves divided by the speed. For the hunt field

$$K_{1a} = \frac{E_{a1}}{I_{11}\omega_1}$$

or the series field the use of a series field saturation curve n a similar manner will ascertain K_{sa}. The ratio of the eries and shunt turns is needed also and this is obtained y generating a voltage with one field separately excited nd then generating the same voltage with the other. When voltages are equal $N_1I_1 = N_sI_s$. Since I_1 and I_s are known, N_1/N_s can be found; this assumes that the leakage paths for the two fields are the same. Thus, from resistance measurements and the open- and short-circuit tests R_1, R_s, R_a, K_a, K_{1a}, K_{sa}, and N_1/N_s can be ascertained, leaving only L_1, L_s, L_a, M_{1s}, M_{1a}, and M_{sa} to be found.

TRANSIENT METHOD

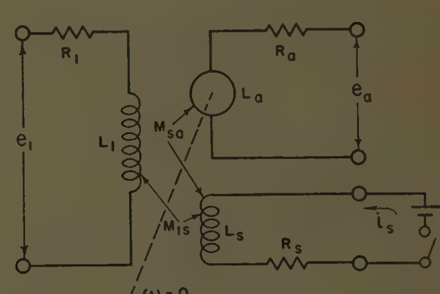
THIS METHOD, first described by Bower,[4] calls for the measurement of the time constants by means of oscillograms when step values of voltage are applied to the various circuit elements. Figure 3*A* shows the circuit necessary to obtain L_1, M_{1s}, M_{1a}, and R_1 (it may be preferable to measure resistances as described in the last section). These values may be checked by taking the decay of current as well when a low value of resistance is connected suddenly across the field terminals. In Figure 3*B* the shunt field resistance is the ratio E_1/i_{10} and L_1/R_1 is t_1. The value of M_{1s} can be determined at any convenient point, t_1, by taking the slope of the shunt field current curve; from which

$$M_{1s} = \left.\frac{e_s}{\frac{di_1}{dt}}\right|_{t_1}$$

While the foregoing test for M_{1s} must be performed while the machine is standing still (to obtain e_s due to mutual induction only) the shunt field time constant may also be determined with the armature rotating. In this case, the time constant of e_a is the time constant of the shunt field. This method has the advantage that, if there are time delays due to hysteresis and eddy current effects, they are included as increases in the control field time constant.

To find the armature circuit parameters, it is best to ascertain the time constants of the armature and series field separately. The series field resistance and time constant may be found in a manner analogous to the shunt field; Figure 4*A* shows the circuit employed. From this circuit it is possible to obtain the self-inductance of the series field, L_s, and the coupling between the series field and the armature circuit, M_{sa}. In the usual d-c machine

Figure 4(A). Transient method of measuring series field self-inductance and mutual inductance to the armature



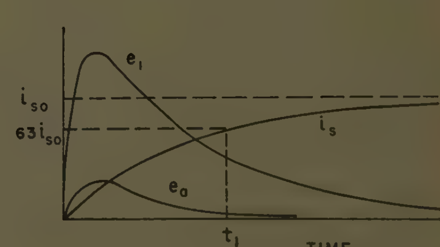


Figure 4(B). Oscillogram resulting from closing the switch in Figure 4(A)

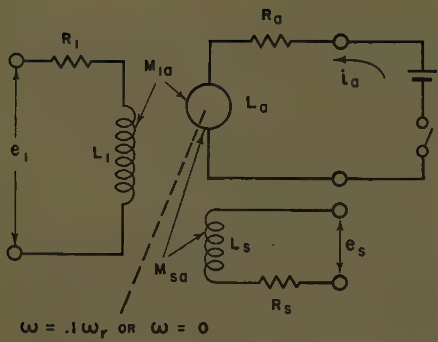


Figure 5(A). Transient method of measuring the armature self-inductance and mutual inductance to the shunt field

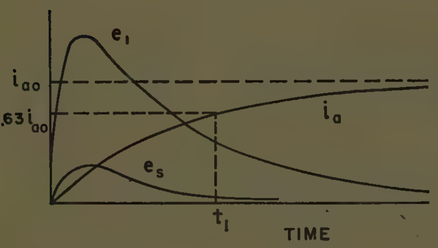


Figure 5(B). Oscillogram resulting from closing the switch in Figure 5(A)

with the brushes set on the neutral, M_{sa} is very small with respect to M_{1s} so that M_{1s} approaches M_{12}, the total shunt field to armature circuit mutual inductance. As before, an alternative test is to measure the rise of e_a as the machine rotates, thus including the delay due to hysteresis and eddy currents. Figure 4*B* shows the transients that occur when the switch in Figure 4*A* is closed.

If the armature proper does not link the series or shunt fields, often the case when the brushes are on the neutral, a test may be made solely for the armature resistance and self-inductance. Even though the rotation of the armature may introduce some extraneous results, it is considered better to have it rotating slowly, say at 10-per cent speed, while the resistance and self-inductance are being found by oscillograms. The slow rotation tends to reflect the proper commutation effects without introducing large ripple and residual voltages which might cause undue error in the results.

Figure 5*A* shows the circuit diagram which is employed for making this test. If the armature does link mutually the series or shunt field, this test should be performed at standstill, that is, with $\omega = 0$ in Figure 5*A*. The oscillogram of Figure 5*B* will permit the obtaining of M_{1a}, L_a, and M_{sa}. According to the development in Appendix I, the armature circuit inductance and mutual inductance to the shunt field when the armature and series field are cumulatively connected in the circuit are

$$L_2 = L_s + L_a - 2M_{sa}$$
$$M_{12} = M_{1s} - M_{1a}$$

As Snively and Robinson[6] point out, and the author concurs, the transient method of testing is not as convenient as the a-c method since a low impedance source of direct current is required as well as the difficulty of interpretation of oscillograms—always somewhat tedious. In addition, it is much more difficult to associate the inductances found by this test with the degree of saturation present in the machine.

A-C METHODS

BRIEFLY, THE a-c method involves the use of alternating current of either low or power frequencies in place of the direct current employed by Bower, measuring the input conditions, and applying transformer theory to obtain the

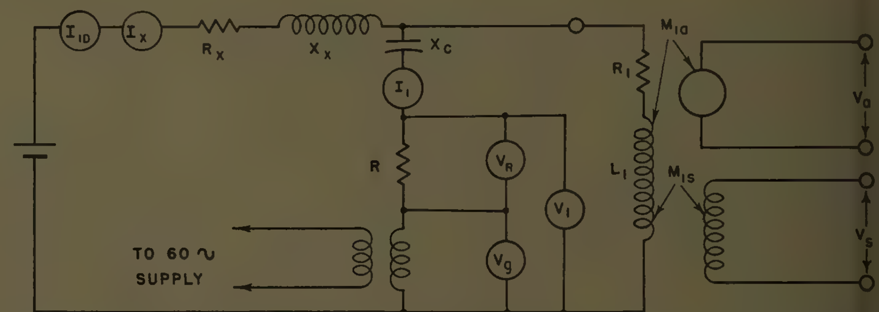


Figure 6(A). Circuit for measuring the machine parameters by a-c tests when provision is made to include the effects of superimposed d-c fields

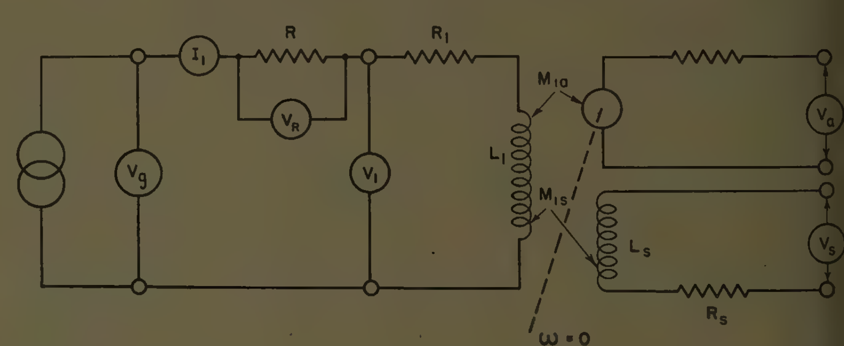


Figure 6(B). Circuit for measuring the same quantities as in Figure 6(A) when no direct current is to be superimposed or when the battery circuit a-c impedance is high compared to that of the d-c machine

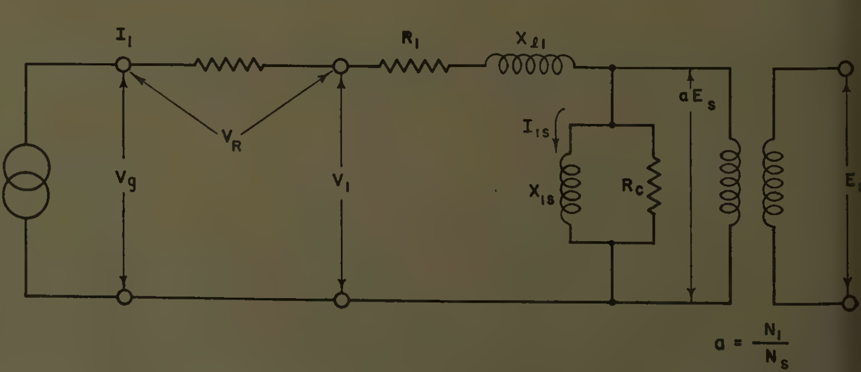


Figure 6(C). Equivalent circuit of the d-c machine while undergoing a-c tests

lesired constants. Consider first the obtaining of self-nductances, L_1 and L_s, and the mutuals, M_{1s} and M_{1a}, of 'igure 1. If the observer wishes to obtain values of nductance as a function of the degree of saturation within he machine, the circuit of Figure 6*A* may be employed.)n the other hand, the circuit of Figure 6*B* may be used f an error of 25 per cent in inductance values can be olerated. The basic difference between the two experi-nental circuits is that the former permits the superposition of a direct current upon the alternating current employed or inductance measurement purposes, while the latter inds the inductances of an essentially unsaturated machine. n Figure 6*A*, the reactor, X_x, serves to block the flow of lternating current through the battery, which usually has a much lower impedance than the field under test. If X_x can be made sufficiently large, then the a-c component of current flowing to the left into the battery circuit will be negligible with respect to the alternating current that lows into the machine under test. If X_c is very small with espect to R, then the circuit of Figure 6*A* may be replaced by that of Figure 6*B*. Assuming that these conditions can be met or that the unsaturated values of inductance are sufficiently accurate, observations of the quantities V_g, V_R, V_1, V_s, V_a, and I_1 are made. From these quantities the vector diagram may be constructed graphically as in Figure 7, utilizing the equivalent circuit of Figure 6*C*. In Figure 7*A* the magnitudes of V_g, V_R, and V_1 are laid off to scale; this fixes the position of the current vector, with respect to the others. In Figure 7*B* the voltages aE_s $(a=N_1/N_s)$ and I_1R_1 are laid off on the original diagram; the vertical projection of I_1R_1 on the radius line $|aE_s|$ represents the magnitude of the I_1X_{l1} drop. Since no current flows in the series field circuit, all the current I_1 flows in the parallel branch consisting of X_{1s} and R_c. Only the current flowing

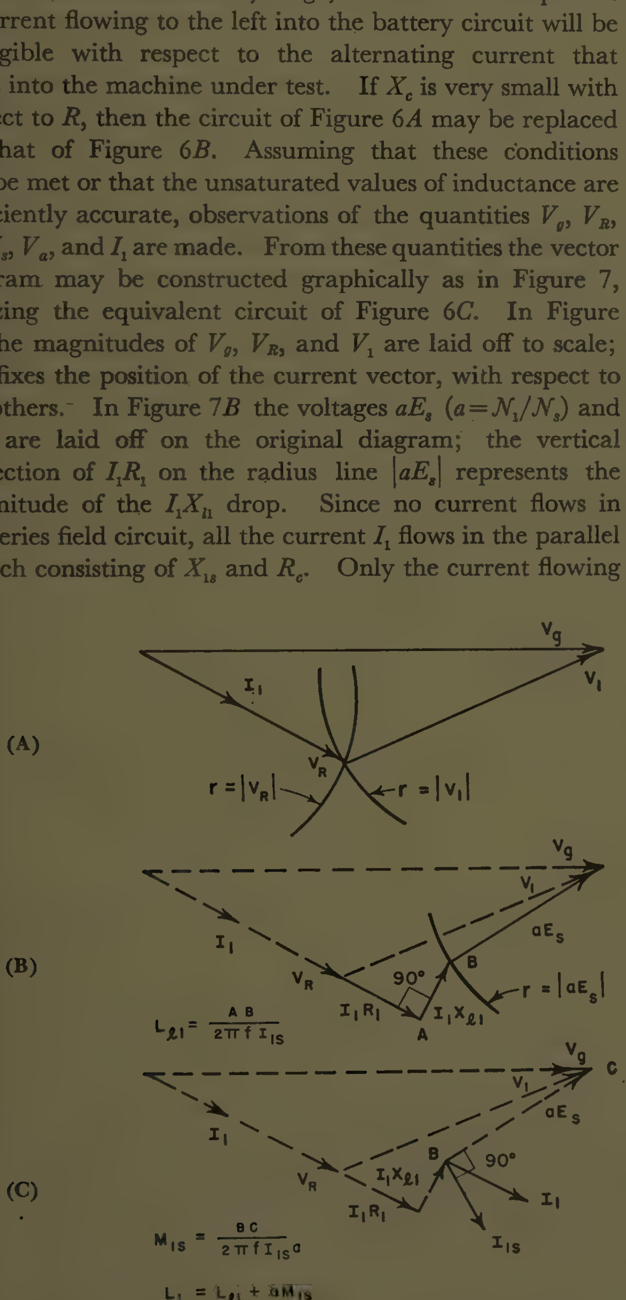


Figure 7. Evolution of vector diagram of the circuit of Figure 6(C) by triangulation methods. Dashed lines indicate vectors of figures above

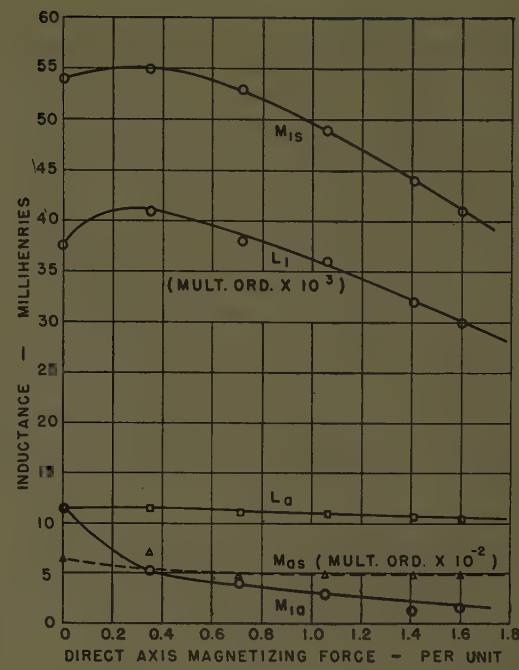


Figure 8. Inductance curves for a 25-horsepower 230-volt 300–700-rpm variable-speed compound motor

through X_{1s} is of interest; this current can be found by separating the current I_1 into its components as in Figure 7*C*. The values of L_1, M_{1s}, and M_{1a} can be ascertained as shown in the inserts of Figure 7.

The series resistor is used to assist in the construction of the vector diagram of the circuit by providing a known phase relationship between one voltage drop and the current; it is not required if some other means may be employed for determining the phase angle between the current and voltage. Vacuum-tube voltmeters or other types of infinite input impedance devices generally are required since the power levels are low. When the power levels are low, the wattmeter becomes unreliable; hence, the circuit of Figure 6*A* is recommended. Care must be exercised to see that reasonably good sine waves are present at all times; this is not difficult in most machines since the air gap is large.

For the series field, the same test yields L_s, M_{1s}, and M_{sa}. For the armature circuit, the same test made with the machine rotating slowly is considered better than a stationary test since the effects of commutation are included in the measurements and yet the ripple and residual voltages are not so large as to influence the results. Because the mutual inductance effects are small in this case, the self-inductance is composed almost entirely of leakage inductance. For that reason the armature self-inductance does not seem to vary greatly with armature current nor with field current.

The results of the test of a 25-horsepower 230-volt variable-speed compound motor with interpoles but no compensating winding are shown in Figure 8. The data for the sample test run are shown as circles and indicate the relative experimental error encountered.

Experience with the machines mentioned herein, which are admittedly small, seems to indicate that it is not correct to assume that the impedance of the armature or any

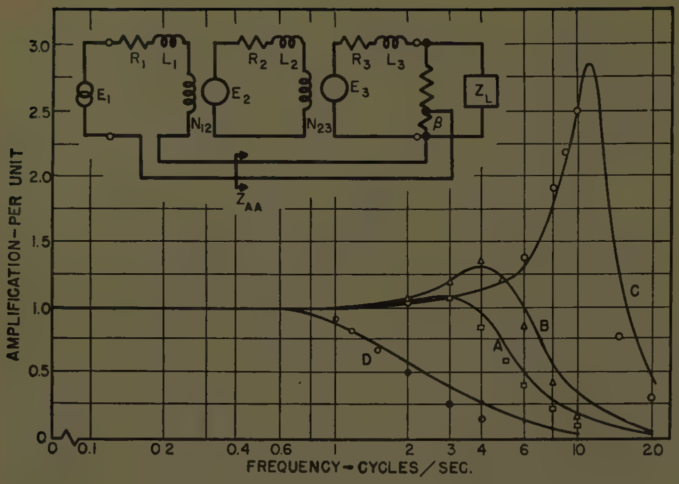


Figure 9. Frequency response curves for a ¾-kw 250-volt Amplidyne as determined by the equivalent circuit shown. Curves A, B, and C are for a β of 10, 20, and 100 per cent negative feedback. Curve D is for zero feedback

other circuit in the machine is predominantly inductive in nature. Serious errors can result by making this assumption. In the author's opinion the presumption should be that the various circuits have resistive components until proved otherwise.

In working with normal armature currents it is recommended that the brushes be left seated in their usual in-service fashion. If this is done, the brush resistance and the inductive effects of the short-circuited coils will be reflected in the over-all parameters of the machine; this is quite desirable in predicting over-all characteristics.

APPLICATIONS

Extensive use of the equivalent circuit and the a-c method of parameter determination has been made by the author and his associates, mainly in the realm of the dynamo-electric amplifier. The Amplidyne probably represents as rigorous a test of these methods as any d-c machine since it is essentially two machines in one magnetic circuit, thus resulting in unusual mutual and self-inductive effects. In the paper[3] on class-*A* operation of dynamo-electric amplifiers, there was very good correlation for an Amplidyne and a Rototrol between experimental and calculated frequency response curves for zero to 100 per cent negative feedback, even though the methods presented in this paper were not as well developed and certain approximations were made. Figure 9 is one set of such curves analytically and experimentally ascertained for a 3/4-kw 250-volt Amplidyne; the equivalent circuit employed for the analytical computations is shown in the inset. It will be noted that there is fairly good correlation between the analytical and experimental curves. Wilson[7] determined the frequency of oscillation of Amplidynes using a capacitively coupled positive-feedback circuit. He predicted the frequency within 7.4 per cent in the region from 5 to 23 cycles per second from a fifth degree operational equation of the loop response employing parameters obtained from a-c measurements.

In operating over the region of Figure 8 of variable inductance, it would be expected that nonlinearities of response would result. Such is not the case in practice; for, even with large changes of field current, the response of the circuit usually turns out to be linear providing the speed-voltage constants, K_{1a}, K_{sa}, and K_a have not changed. In cases of this type it has been observed that the values of inductance chosen should be those associated with the maximum swing of current. For example, if, in Figure 8, it were desired to ascertain the correct circuit parameters for operation with a sine wave of shunt field current equal to 0.8 per unit, the proper inductances would be: $M_{1a}=$ 3.8 millihenrys, $M_{1s}=52$ millihenrys, $M_{as}=0.05$ millihenry, $L_1=38$ henrys, $L_a=11.1$ millihenrys. When operating with d-c values of shunt or control field current, the values used in the equivalent circuit should be chosen for the particular value of current employed.

Appendix I. Combination of Mutual Inductances for a Compound Machine

When the mutual inductance between the armature and the series and shunt fields is appreciable, the following analysis applies which shows how the mutual inductances combine to give one over-all mutual inductance for the coupling between the field and armature circuits. Ignoring the speed-induced voltages, or considering the machine at standstill, the circuit equations in terms of the over-all mutual inductances for a cumulatively compounded machine are

$$e_1=R_1i_1+L_1\frac{di_1}{dt}+M_{12}\frac{di_2}{dt}$$

$$0=R_2i_2+L_2\frac{di_2}{dt}+M_{12}\frac{di_1}{dt}+V_L$$

In terms of the individual mutual and self-inductances

$$e_1=R_1i_1+L_1\frac{di_1}{dt}-M_{1a}\frac{di_2}{dt}+M_{1s}\frac{di_2}{dt}$$

$$e_1=R_1i_1+L_1\frac{di_1}{dt}+(M_{1s}-M_{1a})\frac{di_2}{dt}$$

$$0=R_2i_2+L_s\frac{di_2}{dt}+L_a\frac{di_2}{dt}-2M_{sa}\frac{di_2}{dt}-M_{1a}\frac{di_1}{dt}+M_{1s}\frac{di_1}{dt}+V_L$$

$$0=R_2i_2+(L_s+L_a-2M_{sa})\frac{di_2}{dt}+(M_{1s}-M_{1a})\frac{di_1}{dt}+V_L$$

Hence

$$L_2=L_s+L_a-2M_{sa}$$
$$M_{12}=M_{1s}-M_{1a}$$

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The Squirrel-Cage Induction Generator for Power Generation

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Because of its simplicity, the squirrel-cage induction generator deserves revaluation in the field of power supply. Under appropriate conditions, its low cost and maintenance makes it an economical means of supporting synchronous alternators.

SYNCHRONOUS alternators now are being used almost exclusively as main generating units in central power stations. The reason is obvious: they generate both kilowatts and reactive kilovolt-amperes to suit the load conditions and they produce a standard frequency for synchronization and interconnection. Induction generators usually are installed in relatively small sizes; for although they supply active power, they take reactive current from other synchronous machines. In other words, irrespective of load conditions, the induction generator must operate at leading power factor. However, the induction generator has certain economic advantages in simplified rotor design which is well adapted for high speed operation. It requires no exciter, voltage regulator, or synchronizing and frequency control equipment.

Induction generators and induction motors have many points in common. If an induction motor is driven by outside mechanical source at speeds above synchronism, the power current component in the stator reverses while the magnetizing component remains in magnitude and in phase position, as shown in Figure 1. The machine thus is converted to a generator, and will deliver active power when its shaft input has overcome its internal losses.

It is evident that current of practically equal magnitudes will flow through the stator in the case of generator as in the case of motor at a given slip, which is defined as

$$\text{slip} = \frac{\text{rotor copper loss}}{\text{power transferred across air gap}}$$

As the power is negative with respect to an induction motor because of its reverse flow, the slip is therefore negative. In general, the design principles of the induction generators are identical with those of the induction motors. Since the squirrel-cage rotor is of simple straight construction, the designer can lay emphasis on compactness of the structure and ventilation for thermal dissipation so that it may be, mechanically, strong enough to run at high speed, 3,600 rpm, for large sizes comparable to modern synchronous turboalternators.[1] However, new problems in design may arise with high-speed high-power induction generators. Tooth pulsation loss plays an important role. Totally enclosed rotor slots, magnetic wedges for stator slots, and relatively large air gap may be resorted to. In fact, for a 2-pole large machine leakage reactance is generally low, and, as the short-circuit current is limited by leakage reactance, it is usually necessary to provide extra leakage paths for limiting the transient current.

If an induction generator is brought up to speed and switched to a power line, a large transient current will flow. This will cause disturbance on the line. One method to obviate this inrush would be to connect shunt capacitors corresponding to a somewhat higher susceptance than that of the unsaturated generator. This machine is brought up to synchronous speed and then switched to the line in series with a resistance of 3 to 5 per unit, based upon the generator rating. In case the generator has not built up its voltage before switching, it will build up in a short time and then the resistance may be short-circuited. With this arrangement the disturbance is minimized and the equipment costs very little, since it has only to absorb the heat produced by the relatively small transient current for a very short time. This amount of shunt capacitors may be left permanently connected to the generator. Additional capacitors can be provided as needed.

TYPICAL APPLICATIONS

THE INDUCTION generator can be driven either by low-speed water turbine, or by high-speed steam and gas turbines. The simplicity of operation of a water-turbine-driven induction generator makes it ideal for small hydro sites, say for 1,000 to 5,000 kw, as it requires no skilled

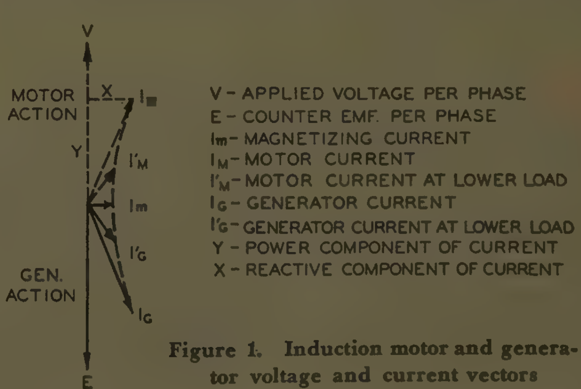

Figure 1. Induction motor and generator voltage and current vectors

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labor and can be run for long periods without inspection.

The induction generator driven by a gas turbine will result in an ideal low-cost power unit. If there are enough synchronous alternators on the existing system to supply excitation current, the addition of gas-turbine-driven induction generators will prove most economical, as shown in Table I, particularly if there is natural gas supply. The induction generator also can be used for generating "by-product" energy in a large power system in conjunction with a throttling turbine to reduce high-pressure steam or natural gas to a lower utilization pressure.

NORMAL AND EXTENDED APPLICATION

INDUCTION GENERATORS of moderate capacity of, say, 3,500 to 10,000 kw per unit are particularly well adapted for a power system, where the excitation current of the induction generator may be derived directly from the alternators. They can be adapted advantageously for systems where there is existing synchronous apparatus such as synchronous converter, synchronous motor, or condenser. For example, the West 59th Street power house of the Interborough Rapid Transit System of New York City has, since 1911, installed five 7,500-kw exhaust-turbine induction generator sets which operate from the steam discharged by five 7,500-kw 25-cycle angle-compounded steam-engine alternators. This increased the thermal efficiency of the plant and doubled its output.

The power generated by these squirrel-cage induction generators is synchronized automatically with the alternators and feeds to the rotary converter substations. The absence of d-c fields leads to the simplest possible switching apparatus, as the induction generator leads are tied in solidly to the synchronous alternator leads (Figure 2), through the knife switches which are never opened.

It was believed, when these induction generators first were installed, that they would have practically zero short-circuit current. However, this is only true with respect to the sustained short-circuit current and does not apply to the transient current. The operation of induction generators is particularly feasible also on systems where there are surplus reactive kilovolt-amperes.

The extended application of induction generator can be classed as for expediency and for large-scale use:

1. Owing to the availability of induction motors as compared to synchronous alternators which were practically impossible to obtain during World War II and also owing to the limitation of power usage imposed during wartime, many factories in the Orient connected induction

Table I. Comparative Equipment Requirements

Steam Turboalternator Set	Gas Induction Generator Set
1. Boilers, condensing plant, and auxiliaries	1. Simple auxiliaries for gas turbines
2. Steam turbine	2. Gas turbine
3. Three-phase alternator	3. Three-phase squirrel-cage induction generator
4. D-c exciter, voltage regulator, synchronizing, and frequency apparatus	4. None
5. None	5. Static capacitors (not needed if the system has surplus reactive kilovolt-amperes)

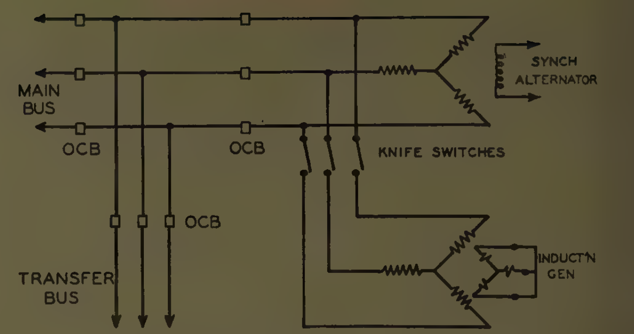

Figure 2. Connection of induction generator with synchronous alternator at West 59th Street Interborough Rapid Transit power house, New York, N. Y.

motors to turbines or any other prime movers, using the supply network for excitation, and, thereby converting them into induction generators, obtained increased power that would otherwise have been unavailable. This expedient application of the induction generators also would be feasible if compensated with capacitors and synchronous motors, as an emergency solution for power shortage.

2. Induction generators in combination with switched capacitors can be used in relatively large-scale installations provided they are tied to a transmission network, at least partly supplied by synchronous alternators governed to maintain frequency. Recent improvements in the manufacture of static capacitors has reduced their price. Their use can be extended to the induction generators as well.

CAPACITOR SWITCHING AND VOLTAGE REGULATION

WHEN INDUCTION generators are installed in a system where there is a shortage of reactive current, the use of shunt capacitors is one of the most economical corrective measures. Shunt capacitors ranging from 2.3 to 13.8 kv at distribution stations and large blocks of high-voltage capacitors ranging from 22 to 44 kv have been installed at transmission stations with good results.[2] In some cases it may be possible to leave the capacitors energized all the time, controlling the reactive output of the synchronous machines to meet requirements. However, the situation may sometime require switching groups of capacitors on and off as needed, see Figure 3.

To avoid flickering or disturbance to the system, the switching of the capacitors should be done in steps. The size of capacitors for each step depends upon the system capacity and load conditions. In a 4-step installation, a magnetic air circuit breaker is used in some cases for overall bank protection and for switching the first step, while the switching devices of following steps are of much lower capacity and may be low-cost interrupters or nonautomatic switches with cutouts, Figure 3. Air-blast circuit breakers may be used, but only when the bank size is, say, over 2,700 reactive kva at 13,800 volts or more.[4]

Voltage control in a power supply system is essentially the balancing of demand and supply of reactive power. If there is a larger demand of reactive kilovolt-amperes than supplied, the line voltage will drop until a new equilibrium is reached. Consequently, automatic control devices for capacitors are preferably designed on a voltage-

sensitive current-compensated basis, but they are only adopted when justified economically.[3]

As an illustration, a synchronous alternator of 30,000 kw rated at 0.8 power factor is supported by two gas-turbine induction generator units of 10,000 kw each at 0.9 power factor; they are to supply a system of a maximum hourly demand of 50,000 kw at an average power factor of 90 per cent. The induction generators will draw reactive power due to excitation and make their own power factor of 90 per cent at full load. Assume the bus load of the station to be 10,000 kw and the load of two substations to be 20,000 kw each. Thus, the capacity and load may be distributed as indicated in Table II.

In this case, the most convenient way is to install two capacitor banks of 6,000 reactive kva each at the primary side of each substation, and leave the balance of the reactive power to be taken care of by adjusting the field of the alternator at the power station. The bank of capacitors may be made of two or three steps so that each step carries about 10 to 13 per cent of the total substation kilovolt-ampere load. The connection of shunt capacitors may give rise to third harmonics. However, this can be obviated by arrangement of transformers and grounding.

This example only intends to explain one of many cases where the use of induction generator may be extended.

SYSTEM STABILITY AND POWER CONTROL

If a short circuit happens during operation, or when switching to a power line with its rotor driven at synchronous speed, the initial stator current of an induction generator is of the same order of magnitude as short circuit at standstill. But the decay of this transient current is very rapid. With large machines (relatively low resistance) it may last a few cycles. Induction generators are also free from voltage surge in any type of short circuit.

It was early believed that induction machines had no tendency to hunt. However, careful analysis[4,5] shows that large induction machines have also a natural oscillation period due to the leakage fluxes. Here again, the attenuation factor is large in comparison with synchronous machines of similar ratings and the duration of mechanical oscillation is much shorter. An induction generator cannot be thrown permanently out of synchronism and will fall in step at any rotor position.

Parallel operation of induction generators with synchronous alternators is excellent. An induction generator will run steadily even though the prime mover may have considerable cyclic power variation.

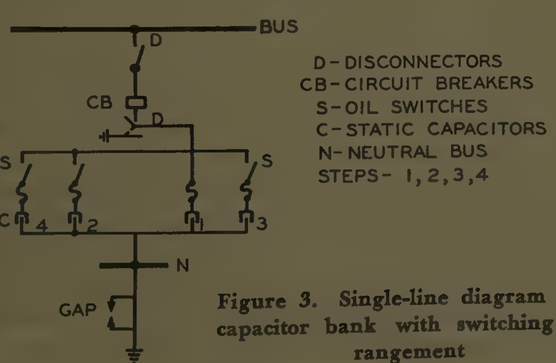

Figure 3. Single-line diagram of a capacitor bank with switching arrangement

Table II. Capacity and Load Distribution of a System

Active Capacity, Kilowatts		Active Load, Kilowatts	
Synchronous alternator	30,000	Substation A	20,000
Induction generator number 1	10,000	Substation B	20,000
Induction generator number 2	10,000	Bus load	10,000
Total capacity	50,000	Total load	50,000
Reactive Capacity, Reactive Kilovolt-Amperes		**Reactive Load, Reactive Kilovolt-Amperes**	
Synchronous alternator	22,500	Substation A	9,800
		Substation B	9,800
		Bus load	4,900
Induction generator number 1			4,900
Induction generator number 2			4,900
Static capacitors required	11,800		
Total reactive capacity	34,300	Total reactive load	34,300

As to the problem of power control in a system of synchronous alternators supported by induction generators, the picture is the same as in systems totally supplied by synchronous alternators. If this system is interconnected with other systems, the synchronous alternators can be provided, as usual, with frequency load tie control, while the prime mover driving the induction generator need only be provided with an ordinary governor of drooping characteristic and an overspeed device.

CONCLUSIONS

1. The squirrel-cage induction generator, due to its simplicity and low cost, is well adapted for supporting large power systems where reactive kilovolt-amperes are available; coupling with gas or water turbines for economical operation; and generating "by-product" electric power where its simplicity of control is a distinct advantage.

2. The application of the induction generator can be extended to any power system by switching in static capacitors in parallel.

3. Although the d-c exciter, voltage regulator, synchronizing, and frequency apparatus can be omitted with the induction generator, nothing can be saved in regard to switchgear since circuit breakers of adequate interrupting capacity are still necessary to handle transient short-circuit currents.

4. No question of stability arises in parallel operation of synchronous alternators with induction generators.

5. Standardization of induction generators will no doubt bring about reduced first cost. A water-turbine-driven induction generator is approximately 91 per cent the cost of an identically rated synchronous machine with exciter. The saving in the induction generator is further obtained by its very low maintenance.

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Telemetering Systems and Channels for a Large Interconnected Power System

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AN ELECTRIC POWER SYSTEM consists of the co-ordinated facilities for generation, transformation, and distribution of electric power within a given area. In large, modern power systems this involves the electrical interconnection of many power sources within the area by means of a transmission system which also distributes the power to major load centers. Interconnection often extends to neighboring power systems in adjacent areas, which, in turn, may be connected to others beyond them, thus creating vast interconnected networks or power pools for economic interchange of power. In the operation of such interconnected systems, there are many and varied applications of telemetering, adopted for labor-saving purposes, for improvement of efficiency in plant and system operation, and for the purpose of automatic load and frequency control, without which extensive interconnected operation would not be feasible.

Telemetering serves many and varied purposes in the co-ordination of a large power system. This article describes some typical applications as they are used in one Canadian system.

The Hydro-Electric Power Commission of Ontario (HEPC) operates four power systems in Ontario. The two largest are the Southern Ontario system and the North-Eastern system which are normally interconnected by a 115-kv tie-line. This integrates some 60 power plants having a capacity of about $2^3/_4$ million kw by means of a network of high-tension transmission lines (115 kv and over) totalling 6,400 circuit-miles, in an area about 500 miles east to west and 500 miles south to north.

Statistics of high-tension line mileage, peak loads, HEPC generating capacity, and total interconnected generating capacity are given in Tables I, II, III, and IV respectively.

Ontario is also interconnected at times with systems in New York State, and the chain sometimes extends as far south as Washington, D. C. Future interconnections may include neighboring provinces and states, in a trend which points toward ultimate formation of one great power network blanketing the whole continent, with generators running in synchronism throughout. The control of power distribution in such extensive networks demands continuous, reliable telemetering of power measurements from boundary points of each area to an area control center where automatic equipment regulates the output of generators within the area, thus maintaining the desired transfer of power to or from the neighboring areas.

Except in a few cases where special equipment was designed and built locally, commercially available equipments have been selected which economically fulfill the physical requirements of the application. Commercial accuracy is usually in the order of one per cent of range which is acceptable for most applications. Selection of makes and types is dependent upon the type of transmission channel available, required speed of response, available power supplies at transmitting and receiving ends, and other factors.

Standardization is desirable, thus permitting a reduction in the supplies of spare parts and meter charts which must be kept in stock, but with rapid development of the art adherence to standardization is difficult.

BASIC TELEMETERING TYPES

THE FIVE BASIC types of telemetering systems defined by the AIEE[1] are current type, voltage type, frequency type, position type (or ratio type), and impulse type (with subtypes).

Fields of application of these types on the Commission's properties are

1. Current Type, such as Torque Balance: for telemetering mechanical motions or electrical quantities over distances up to a few miles on 2-conductor wire circuits.

2. Voltage Type, such as thermal converters with self-balancing potentiometer recorders: for telemetering electric power measurements over distances up to 20 miles on 2-conductor wire circuit, with or without totalizing, for example, load of one or more generators, generating stations, transformers, or feeders.

3. Frequency Type. Though not at present used by the Commission, this type is capable of high speed of response, and can be used to telemeter mechanical or electrical quantities over wire circuits or carrier channels which are adapted to pass the desired band of frequencies.

4. Position Type (Ratio Type), such as Selsyn or Autosyn, and rectified current system: for telemetering mechanical motions at distances up to a few miles, over wire circuits, for example, water level, turbine gate position, gate limit setting, governor speed setting, transformer tap-changer position, wind direction indicator.

Essentially full text of paper 51-229, "Choice of Telemetering Systems and Channels for a Power System," recommended by the AIEE Committee on Telemetering and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Table I. High-Tension Line Mileage Data

December 1950

System	Voltage, Kv	Circuit Miles
South Ontario	230	2,693
South Ontario	115	2,638
North-East Ontario	115 to 138	1,069
Total		6,400

Table II. HEPC Peak Loads (Actual Load Carried)

December 1950

System	Megawatts, 20-Minute Peak		
	25-Cycle*	60-Cycle	Combined
South Ontario	1,577	571	2,148
North-East Ontario	165	74	239
Total			2,386

* Includes Dominion Power $66^2/_3$-cycle load.
Note: 25-cycle and 60-cycle peaks are not necessarily coincident. Loads are given in terms of power generated and purchased.

5. Impulse Type, such as Chronoflo, Metameter, Micromax Ballistic: for telemetering mechanical or electrical quantities over wire circuits and carrier on telephone lines, power lines, or radio, by channels capable of transmitting a keyed signal.

Examples will be cited to illustrate the application of different types of telemetering in the Commission's power plants, then in regional operation, and finally in system operation.

TELEMETERING IN HYDRO PLANTS

One of the most important factors in the operation of a hydroelectric power plant is head-water level and, to a lesser degree, tail-water level, since these determine the efficiency, capacity, and stored energy available at a plant. In some plants the levels at more remote points upstream or downstream are also important because of effects on navigation or other interests. To provide an indication in the control room of such quantities requires the aid of telemetering. The two types most commonly used are the well-known position type (Selsyn, and so forth) and impulse duration type, operated from a float in a float well. At Sir Adam Beck-Niagara number 1 plant on the Niagara River both types are in use for forebay level indication in the control room in case either float becomes fouled with ice or debris. Also, the impulse telemeter is used for transmitting to the regional operator's office at Niagara Falls and to the system supervisor's office at Toronto.

Rectified Current, Ratio-Type Telemeter. Conditions at the Chats Falls plant on the Ottawa River led to the choice of the Evershed-Midworth rectified current telemetering system for remote water-level indication. The transmitter is located at a point where no power supply is available. The equipment operates on a-c supply which is passed through the transmitter and receiver in series, using only two line wires. A float-operated rheostat or current divider and two half-wave rectifiers at the transmitter determine the proportions of positive and negative half-waves of current which are allowed to flow in the circuit. The receiver is a d-c ratio-type indicating instrument with two coils which are supplied through rectifiers so that one is energized by the positive half-waves and the other by the negative half-waves of the alternating current. Operation has been satisfactory except for effects of dampness and ice at the transmitter, in the absence of electric heating. Obstruction of the float or water passages by ice was avoided by the use of oil instead of water in the float well.

Voltage-Type Telemetering and Totalizing. Electrical quantities within a power plant usually can be measured without resort to telemetering, but, for its convenience and adaptability, plant totalizing by means of thermal converters and a self-balancing potentiometer recorder recently has become standard HEPC practice.

The thermal converter is a device which, with no moving parts, converts an a-c power measurement into a d-c millivoltage proportional to the a-c power. Separate measurements may be added by connecting the d-c outputs of two or more thermal converters in series. Subtraction may be effected by reversing the d-c polarity. Since the d-c output automatically reverses its polarity when the direction of power flow reverses, the thermal converter is useful also for measurement of power in tie-lines. A 2-wire circuit is required for connection to a receiving potentiometer, and since this is a sensitive, null-balance instrument, resistance of 1,000 ohms or more can be tolerated in the input circuit. This represents many miles of transmission, even with small wire sizes.

This is an application of voltage-type telemetering, even

Table III. HEPC Dependable Generating Capacity, Southern Ontario and North-Eastern Systems

December 1950

System	Number of Plants		Total Capacity (Megawatts)		Total Capacity (Megawatts)
	Hydro	Other**	25 Cycle*	60 Cycle	
South Ontario	39	6	818	598	1,416
North-East Ontario	18		202	93	295
Total	57	6	1,020	691	1,711

** Small steam and diesel plants.
* Includes 45 megawatts of $66^2/_3$-cycle generation.

Table IV. Interconnected Generating Capacity, Southern and North-Eastern Ontario Systems

December 1950

System	Total Capacity (Megawatts)		Total Capacity (Megawatts)
	25 Cycle	60 Cycle	
South Ontario	1,562	728	2,290
North-East Ontario	330	120	450
Total	1,892	848	2,740

Note: Includes generating capacity of customers and suppliers, operated in parallel with the Commission's systems. Does not include systems in the United States.

though the distance of transmission is not great in the case of local plant totalizing. Potentiometer recorders can be purchased which are built to incorporate impulse transmitters for retransmission of the measurement by impulse-duration telemetering to more remote regional and system operating centers.

TELEMETERING IN REGIONAL OPERATION

To co-ordinate the operation of two or more plants in a local area, telemetering must extend to greater distances. A common case is that of two or more generating stations on one river, where the water passes through each plant in turn, and where the discharges of the plants must be co-ordinated. Frequently one or more such plants are operated as unattended stations by remote control. This usually requires more telemetering than when the plant is attended.

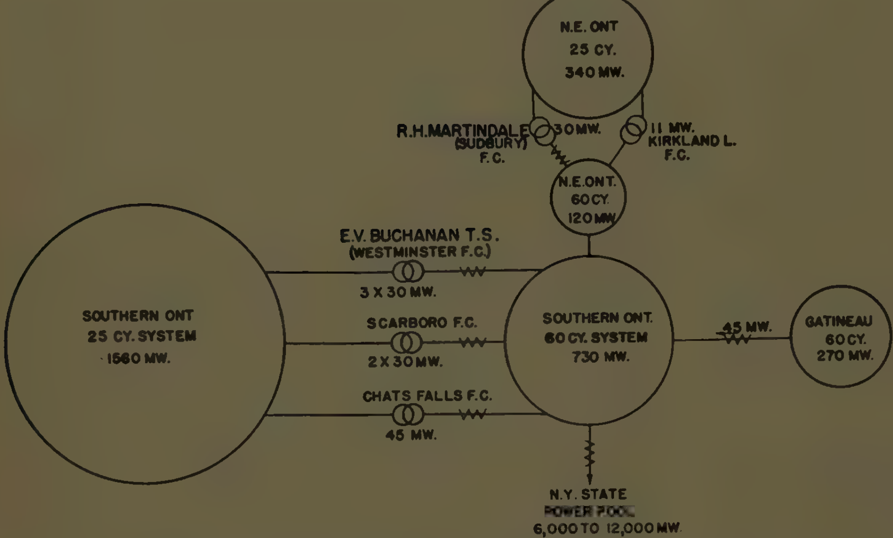

Figure 1. HEPC system interconnections, southern and northeastern Ontario

Current Type Telemeter. A typical example is that of two small plants, one of which, an unattended plant of 7,000-kw capacity, is controlled from a plant about three miles further up the river. Torque-balance telemeters are used to give continuous indications of forebay elevation, gate positions, and kilovar outputs of the two generators at the unattended plant to guide the operators in adjusting load and voltage.

The torque-balance telemeter is one of several makes of current type telemeters in which a direct current proportional to the measurand is transmitted to an indicating or recording milliammeter at the receiving end. The torque of the primary measuring device is balanced against that of a permanent-magnet moving-coil element in series with the transmission current. The transmitted current is automatically adjusted to maintain the balance. Totalizing may be accomplished by paralleling the outputs of different transmitters. Accuracy is not affected by changes in circuit resistance or by variations in supply voltage. Transmission distance in the case cited is 18,000 feet, using pairs of number 19 gauge rubber-insulated conductors in an overhead lead-covered control cable, but the system is usable over much greater distances. This torque-balance system requires a power supply at the transmitting end only.

Supervision of Niagara Region. A more extensive installation of telemetering for regional supervision exists in the Niagara district, where five large hydroelectric plants discharge water the aggregate amount of which must be limited, as provided by international agreement. In the case of four plants, the water consumption is calculated from the measurement of electric energy output, while in the fifth (De Cew) the water is controlled and measure where it is diverted from the Welland Canal through pipes. Discharge through these pipes is totalized and telemetered by impulse-duration system to De Cew plant where it is recorded and also integrated. Each of the five plants operates at a different head and therefore optimum efficiency in use of the total available water requires careful supervision of the loading of these plants.

At the regional load supervisor's office at Niagara Falls, potentiometer recorders operate from thermal converters in the several plants to indicate plant loads; also three impulse-duration type water-level telemeter receivers show forebay conditions at three of the plants. All these telemetering transmissions are through pairs of wires in lead-covered control or communication cable. The longest run is about 14 miles, in which a pair of number 19 gauge wire of 1,200 ohms loop resistance connects thermal converters at De Cew plant to a potentiometer recorder at the regional office at Niagara Falls. Maximum millivoltage in the measuring circuit is 238 millivolts.

The five load recorders at Niagara supervisor's office are built as impulse transmitters for retransmitting the load readings to the system supervisor's office in Toronto. Two of the water-level indications are transmitted to Toronto also.

Other facilities at Niagara office include a Selsyn-type wind-direction indicator and d-c tachometer-type wind-velocity indicator operated from transmitters on a tower a few hundred yards from the office. One unique facility which is available not only to the Niagara load supervisor but to any plant operator and others who have telephones connected to the HEPC private automatic exchange is an audible indication of water level at any of four water-level gauge stations located on the upper Niagara River and along the 12-mile route of the canal which conveys water from the upper river to the Sir Adam Beck-Niagara number 1 power plant.

Although the water level indication is audible instead of visible, and is "as-called-for" instead of being con-

tinuous, the system qualifies as telemetering of the impulse-counting type.

Totalizing City Loads. A regional problem which occurs in a municipal load area is that of totalizing the power demand of a municipality which purchases power on a peak demand basis. For example, in the city of Toronto, power is delivered at seven stations at each of which graphic meters are installed as the basis of billing. To determine from seven different charts the time when the maximum combined demand occurred is a very onerous task with much risk of error, but a potentiometer-type totalizer, supplied by thermal converters in the various stations, gives the time of the peak, and normally agrees with the total as measured by the seven individual meters within one per cent. The Toronto load supervisor, in whose office the totalizing recorder is installed, also uses its indications as a guide to operation. In this installation there are now 30 thermal converters connected in series through 20 circuit miles of small-size conductor in multi-conductor communication cable. Total loop resistance is about 1,600 ohms.

TELEMETERING IN SYSTEM OPERATION

SUPERVISION OF a large interconnected power system aims at the most efficient utilization of all power resources. Provision must be made for meeting all load demands as they change from minute to minute and from hour to hour, and for maintaining suitable voltage levels at load centers. Hence the systemf supervisor requires an indication o these changing loads as they appear in the output of major generating stations and in the loads of tie-lines and frequency changers interconnecting different systems or divisions within a system. This requires system-wide telemetering, since generating stations and tie-lines are likely to be far from the supervisor's office. Figure 1 shows a schematic diagram of the interconnected systems in Ontario and adjacent areas.

Modern practice is to regulate the output of key generating stations in each system or division of an interconnected group so that each area takes care of its own load changes and tie-line loads are maintained at scheduled values. Such regulation is done by automatic controllers which are sensitive to changes in the tie-line loads and also to system frequency, hence called load-frequency control. When deviations occur in either load or frequency, the controllers send out raising or lowering impulses which are transmitted to the turbine governors of generators in the selected regulating plants, causing them to change their output to restore scheduled conditions. Other plants tend to hold constant load except when changed by manual control. The variable quantities—regulating plant loads and tie-line loads—are therefore the most important quantities to be telemetered. Tie-line telemetering, being a link in a closed-loop automatic control system, should possess a high degree of reliability and speed of response.

System Supervisor's Office, Toronto. Supervision of the HEPC Southern Ontario system is conducted from an office in Toronto, to which are telemetered, at present, the loads of three 25-cycle generating stations, two 60-cycle generating stations, three frequency-changer stations, one 25-cycle and four 60-cycle tie-lines, and two forebay levels. Two load-frequency controllers are located in the Toronto office, one for control of the 25-cycle division and the other for the 60-cycle division. Niagara plants (Sir Adam Beck-Niagara number 1 or De Cew) are used for 25-cycle system regulation and plants in Eastern Ontario for 60-cycle regulation. Figure 2 shows the metering and control panel in the system supervisor's office, Toronto.

Long-Distance Telemetering. For long distances of transmission over channels of variable attenuation the frequency system or some form of impulse system is most suitable, since the accuracy of the system is not dependent upon the magnitude of the electrical quantity in the transmission circuit but only upon some time function such as frequency, impulse duration, impulse rate, or impulse spacing. Another advantage is the simplicity of relaying the signal as often as necessary to span any desired distance.

Among impulse systems, the most commonly used in power-system applications is the impulse-duration type in which impulses recur at fixed intervals, called the impulse period, and individual impulses have a duration dependent upon the magnitude of the measurand. The ability of this system to follow a rapidly changing variable depends largely upon the impulse period which is usually between 2 and 15 seconds, depending upon the make and the application. Short impulse periods give faster response but require more critical adjustments of instruments and

Figure 2. Telemeter and control panels in system supervisor's office

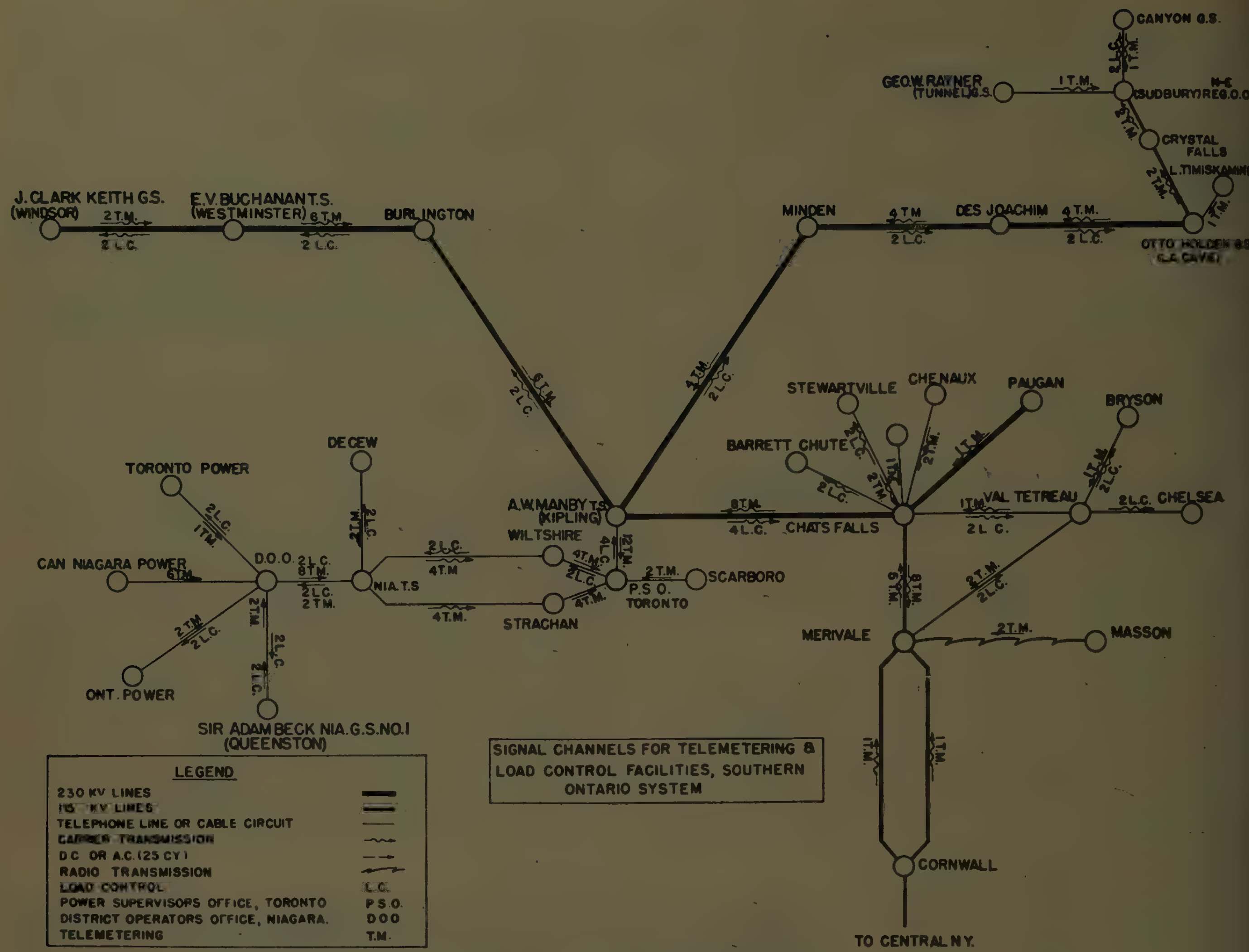

Figure 3. Signal channels, present and projected, for telemetering and control of the Southern Ontario system

also of the channel equipment used for transmission.

With the exception of two local load measurements, which use potentiometer recorders connected by cable circuits to thermal converters at Scarboro, all load telemetering to the Toronto office is impulse-duration type, using almost exclusively Leeds and Northrup Micromax Ballistic telemeters. The primary measurement at the transmitting points is by thermal converters and potentiometer recorders, which produce telemetering impulses at 2.4-second intervals. The impulse duration varies between 0.1 and 2.0 seconds in accordance with changes in the load measurement. At the receiver, the incoming impulse applies a slow rate of charge to a capacitor, which at the end of the impulse retains a voltage proportional to the impulse duration. Mechanically operated contacts then transfer the capacitor to the measuring circuit of the potentiometer recorder by which the voltage is measured, after which the capacitor is discharged and connected again to be charged by the next incoming impulse from the transmitting point.

The over-all speed of response of such a load-telemetering system is the combined time delay of the thermal converters and of the telemetering instruments. For tie-line measurements, where automatic control is involved, thermal converters are specified which measure 90 per cent of any load change in one second or less and the over-all speed with 2.4-second impulse period is satisfactory for control purposes under average conditions.

Each load-recording telemeter at Toronto has in it a retransmitting slide-wire or voltage divider. In the case of tie-line load recorders these slide-wires feed into the appropriate system net interchange controller. In the case of generating station load recorders, the retransmitting slide-wires are used for local totalizing. Since some plant outputs are not at present telemetered to Toronto, the loads of these, reported by telephone, are injected into the total by means of manually adjustable voltage dividers, so that an approximate record of total system generation is obtained.

TELEMETERING AND CONTROL CHANNELS

THE TWO PRINCIPAL kinds of channel for telemetering and associated remote control are wire circuits (sometimes called pilot wires) and carrier on existing telephone lines or power lines. The simplest channel is a wire circuit used for no other purpose, in which case any of the five basic types of telemetering may be used up to distances which may be limited by line resistance or leakage or by

economic considerations. Open-wire lines are somewhat vulnerable to variable leakage, weather hazards, and inductive interference. Lead-covered cables are more reliable, especially when laid underground in ducts. One pair may be used for two or more channels by using different audio-frequency signals which, of course, are useable only for frequency-type or impulse-type telemetering, though d-c telemetering (current type) may be used simultaneously on the same pair.

Telephone-line carrier often is used as an economical long-distance channel where open-wire telephone lines already exist and where reliability is not of the utmost importance. Frequencies in the range from 12 to 25 kc may be applied for several channels of impulse-type telemetering without interfering with the physical voice channel and one voice carrier in the band between 5 and 10.5 kc. Distances of 100 miles or more can be spanned without repeaters on well-built and properly transposed lines, using by-pass filters at intermediate terminals and blocking filters on tap lines. Attenuation is roughly 0.1 decibel per mile and the input power level is in the order of 16 decibels (above one milliwatt into 600 ohms) on each channel. Coupling to the line at each terminal is through a band-pass filter.

Power-Line Carrier. Greatest reliability is attained in the use of carrier channels on the high-voltage power lines which are built to withstand very severe weather conditions. Coupling is by means of a high-voltage capacitor connected between one line conductor and ground, with a choke coil in the ground lead. A line trap is usually connected in series with the line conductor between the terminal station and the point of connection of the coupling capacitor, to prevent dissipation of the carrier within the local station or its transmission into other circuits where it might cause interference with other carriers. A carrier may be connected between one power conductor and ground or between two power conductors, each equipped with couplers and traps, or both types of coupling may be used simultaneously with different carrier frequencies, which requires line traps tuned for two frequencies. The carrier frequency used in this system is in the band between 50 kc and 300 kc.

The simplest use of a carrier is to key it on and off for impulse telemetering of a single quantity, but greater use can be made by modulating it with a number of audio-frequency tones, each of which can be keyed as a separate telemetering channel. Carrier frequencies and tones must be chosen to suit the line attenuation characteristics and to avoid interference between carriers on different lines in the same area. The tone frequencies also must be selected to avoid mutual interference and interference from harmonics of the power system frequency. Another method of keying a carrier is by the "frequency-shift" system, in which the carrier is shifted by the telemetering signal, between two values, both crystal-controlled, which are close enough together to be passed or blocked by a single filter or choke, but far enough apart for adequate discrimination.

Table V. Channel-Miles of Carrier in Service on Southern Ontario System

April 1951

	Channel Miles: Telephone-Line Carrier	Channel Miles: Power-Line Carrier
For load control	642	860
For telemetering	1,023	2,600
Total	1,665	3,460

Channels suitable for telemetering are useable also for various other kinds of signalling and control such as raising and lowering load-control signals, for supervisory control of circuit breakers and other equipment, and for the automatic tripping of faulty lines. Such applications are increasing in number continually so that means of crowding more channels onto the existing power lines always are being sought.

For line-of-sight routes, radio channels, either short wave or microwave, are entering the field as competitors of other means of transmission and they have an economic advantage in some cases.

The HEPC of Ontario in 1950 placed in operation its first power-line carrier telemetering and control channels on a 230-kv power line between Toronto and Chats Falls plant (near Ottawa), a distance of 214 miles, using 71 kc for incoming telemetering and 97 kc for outgoing load control, both coupled to the same two line conductors. Tone frequencies between 200 and 3,000 cycles are used to modulate the carriers to give a maximum number of eight channels each way. Additional tone-modulated carrier and also some frequency-shift carrier are being installed on other lines. Radio channels for telemetering have been tried experimentally between Masson and Merivale in the Ottawa area with encouraging results. The distance is about 23 miles, using high-gain directional antennas at an elevation of 325 feet and 100 feet above ground at the two terminals respectively. Trials to date have been with 1-way transmission at 158.25 megacycles, using frequency modulation for one voice channel, and it is planned to add two tones at frequencies above the voice band for impulse-duration telemetering.

Defining a channel as a path which is suitable for the transmission of any single control or telemetering signal, the number of channel-miles of telephone-line and power-line carrier at present in use for telemetering and control on the Southern Ontario system are summarized in Table V. The diagram of Figure 3 shows schematically the routes of present and projected carrier channels and also of wire circuits (mostly in cable) associated with them.

Telemetering has proved itself to be an essential tool in the efficient operation of electric power plants and interconnected systems. The number of applications is continually increasing as systems grow and interconnections are extended, predicated upon the reliability of telemetering instruments and channels, and automatic controls associated therewith.

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Equivalent Machine Constants for Rectifiers

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THE CALCULATION of fault currents in short-circuited rectifiers is given in an AIEE committee report,[1] but it does not give any information on faults which fall in the region between high overloads and short circuit, nor for calculation of fault currents resulting from short circuits at distant points of extensive d-c systems.

For this purpose it would be very desirable to substitute for each connected machine an equivalent machine having constant induced electromotive force, and linear internal resistance and inductance. To arrive at a set of equivalent constants for a rectifier, the complete regulation curve of the rectifier from no-load to short circuit is needed.

The two most commonly used rectifier circuits are the 6-phase double-Y, for low-voltage mercury-arc rectifiers, and the 6-phase double-way, for the mechanical rectifier. These are circuits 45 and 23 respectively of the American Standards Association Standards C34.1-1949.[2]

The drop in d-c voltage due to commutating reactance, expressed in per-unit quantities, is the same for the 6-phase double-Y and double-way circuits. The drop increases linearly with current until the angle of overlap $u=60$ degrees and then drops off sharply. For a given voltage drop, the current in a noninductive d-c circuit is $2\sqrt{3}/\pi$ times greater than the current in a highly inductive circuit. The complete regulation curves are shown in Figure 1.

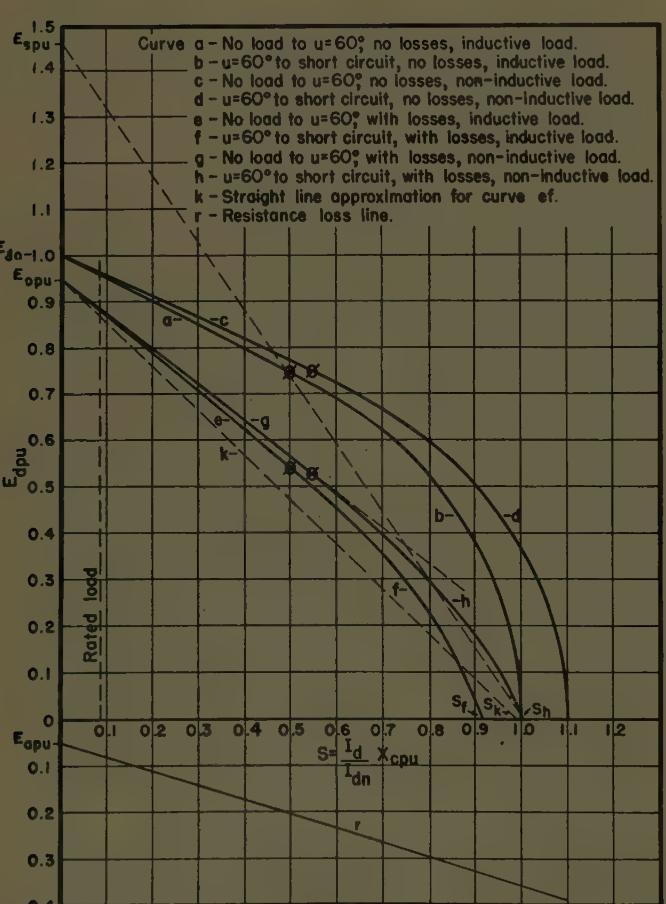

Figure 1. Regulation curves for rectifiers

For an inductive d-c circuit, from no load to $u=60$ degrees

$$\Delta E_d=\frac{1}{2}\frac{I_d}{I_{dn}}X_{cpu}E_{do} \tag{1}$$

and from $u=60$ degrees to short circuit

$$\Delta E_d=\left[1-\frac{1}{2}\sqrt{3}\sqrt{1-\left(\frac{I_d}{I_{dn}}X_{cpu}\right)^2}\right]E_{do} \tag{2}$$

For a noninductive d-c circuit, from no load to $u=60$ degrees

$$\Delta E_d=\frac{\pi}{4\sqrt{3}}\frac{I_d}{I_{dn}}X_{cpu}E_{do} \tag{3}$$

and from $u=60$ degrees to short circuit

$$\Delta E_d=\left[1-\frac{1}{2}\sqrt{3}\sqrt{1-\left(\frac{\pi}{2\sqrt{3}}\frac{I_d}{I_{dn}}X_{cpu}\right)^2}\right]E_{do} \tag{4}$$

in which E_d is the d-c output voltage, E_{do} is the induced d-c voltage at no load, I_d is the load direct current, I_{dn} is the rated direct current, and X_{cpu} is the per-unit commutating reactance.

From these equations and the known losses, the actual regulation curve for the machine can be constructed. By approximately matching the actual curve with one or more straight lines, equivalent electromotive forces and resistances can be found for steady-state d-c analyses.

For overloads not exceeding $0.55\ I_{dn}/X_{cpu}$, the equivalent internal inductance of the rectifier is very nearly $1/2\ X_c/2\pi f$ for the double-Y and $2X_c/2\pi f$ for the double-way circuits.

For short circuit or near short circuits the current rises to a peak in the first 1/2 or 2/3 cycle and falls back quickly to the steady-state value. This transient peak is greater than the steady-state current by a factor K which is equal to $1+e^{-3.22\ R_c/X_c}$ in which R_c and X_c are the resistance and reactance of the commutating circuit. The approximate time constant of the equivalent machine can be taken as $1/2\pi f$, from which the equivalent inductance can be found.

If the inductance of the d-c circuit to the fault is greater than $20X_c/2\pi f$ for the double-way rectifier, or $5X_c/2\pi f$ for the double-Y, the transient peak will not occur.

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Digest of paper **51-207**, "Equivalent Machine Constants for Rectifiers," recommended by the AIEE Committee on Electronic Power Converters and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Not scheduled for publication in AIEE *Transactions.*

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Co-ordination of a Power-Line Carrier Network

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RECENT EXPANSION in generating capacity of the Hydro-Electric Power Commission of Ontario, together with the policy of centralized control, has necessitated a power-line carrier channel mileage of approximately 16,000 operating over 2,600 circuit miles of the power network. Complexities in operating conditions and requirements, and a limited frequency spectrum, 50–200 kc, require quantitative measurements and consideration of the more important transmission factors in the co-ordination of a power-line carrier network.

The physical layout of a power system network has a direct bearing on the amount of carrier interference to be expected. Parallels and lengths of transmission lines, as well as variable dimensions such as spacing, height, and diameter of power conductors, and horizontal and vertical separation of disturbed and disturbing conductors, must be considered. The effect of these factors may be computed but the work is tedious and the results are approximate. Quantitative results can be obtained best by field measurements.

Attenuation measurements were made on numerous circuits of varying length and configuration. A study of the attenuation over the carrier-frequency spectrum has led to these empirical equations

$$N=(0.5f\times 10^{-3}+0.1)d \quad (1)$$

$$N=(0.4f\times 10^{-3}+0.06)d \quad (2)$$

where N is total attenuation in decibels; f is frequency in kc; and d is length of line in miles.

Equations 1 and 2 may be used to calculate the phase-to-ground and phase-to-phase attenuation respectively. These equations are approximate in that they are derived from over-all average values. However, results of sufficient accuracy can be obtained to predict the behavior of a carrier wave on lines in excess of 50 miles. Measured results will not show smooth variation of attenuation with frequency but will vary with wire type and size, length of circuit, ground resistivity, insulator type, wire spacing, method of coupling, tapped lines, and so forth.

Impedance measurements made on lines with the reactance of the circuit and coupling equipment tuned out showed that phase-to-phase impedance was more than that for phase-to-ground. Average values approached 287 ohms for phase-to-ground and 413 ohms for phase-to-phase.

The output power level of transmitting equipment is selected to provide an adequate signal-to-noise ratio at the carrier receiver terminals. The noise voltages will depend upon the operating voltage of the power circuit and the type of transmission employed, that is, phase-to-phase or phase-to-ground. The value of noise measured with test instruments is difficult to relate to that obtained under actual operating conditions. However, the results will indicate the noise variation with frequency. Noise in the carrier band of frequencies was measured on energized 230- and 115-kv lines. The measured value of the noise on the 115-kv lines tested was found to be less than 70 decibels below 1 milliwatt with the line energized and de-energized. The phase-to-phase noise voltages are less than the phase-to-ground voltages. Further, for the de-energized line, they decrease linearly with frequency and increase linearly with the line energized.

CONCLUSIONS

1. Far-end and near-end cross-coupling vary with frequency and method of coupling, with the average cross-coupling loss generally increasing with frequency and separation of disturbed and disturbing circuits. Optimum use of coupling losses for carrier frequency co-ordination in a power network can be utilized only if measured values are available with noise and attenuation factors.

2. Attenuation on phase-to-phase transmission is less than that for phase-to-ground and in either case increases with frequency and varies with circuit configuration. It is possible to calculate the average attenuation with frequency from equations 1 and 2 for engineering purposes, and on transposed circuits the attenuation is essentially the same irrespective of which phase wires are employed.

3. The impedance of any circuit varies with line configuration and is higher for phase-to-phase than for phase-to-ground and at the higher frequencies tends to approach a constant value.

4. The amount of noise voltage present in the carrier spectrum is greater for 230-kv than 115-kv lines and is more for phase-to-ground than phase-to-phase. Certain field measurements of noise level in energized and de-energized lines show respectively: (a) a linear increase with frequency and (b) a linear decrease with frequency.

5. In view of the transmission characteristics of high-tension lines, carrier relay receiver selectivity characteristics, and the intermittent but important nature of relay carriers, it appears advisable to allocate the frequency spectrum 50–100 kc for this type of service and the spectrum from 100–200 kc for communication, telemetering, and load control purposes.

It is practical to use common frequencies for maximum utilization of the allocated carrier-frequency spectrum where interference is low because of the geographic separation of equipment or where interference is relatively high as in the case of adjacent circuits by the optimum selection of transmission and equipment characteristics.

Digest of paper 51-246, "Transmission Considerations in the Co-ordination of a Power Line Carrier Network," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Hermetically Sealed Components for Industrial Control

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Today many different types of components are available in hermetically sealed units. These, though initially expensive, may prove worthy, because components last longer, maintenance is easier, and the parts are relatively tamperproof.

SEALED MOTORS, explosion-proof switches, hydrogen-cooled generators, and sealed refrigerating units have been used in the industry for many years However, until very recently very little was done in the sealing of electric circuit components. The adverse climatic conditions to which military electric and electronic equipment was exposed during World War II caused a major change in assembling and "packaging" of electric control components. In 1943, Navy records[1] indicated that 95 per cent of the failures of electric equipment in instruments were due to extremely difficult climatic conditions and only five per cent were due to mechanical failures and electric breakdown. Investigations of this problem, together with records obtained from related equipment, showed that the most satisfactory solution could be obtained by hermetic sealing of electrical components. In this way the cleanliness and atmospheric conditions which surround the electrical components can be controlled accurately and maintained throughout the life of the equipment.

Today a great variety of hermetically sealed components are available ranging from transformers, magnetic amplifiers, choke coils, and quartz crystals to instruments relays, dry rectifiers, vibrators, timers, and flashers.[2–4] Even power transformers up to 1,000 kva have been gas-filled and hermetically sealed. The hermetic sealing of these components protects them not only against adverse climatic and environmental conditions but also greatly simplifies maintenance and replacement and still further renders them tamperproof.

Courtesy Hermetic Seal Products Company

Figure 1. Multiterminal glass-to-metal seal headers with all conductors fused at one time

In industry, typical conditions for the use of hermetically sealed components exist in steel mills, metal refineries, paper and textile mills, foundries, chemical plants, food processing plants, and similar enterprises in which contaminated surroundings cause breakdowns of electric equipment.

The truly hermetically sealed component consists of four parts: terminal seal, envelope, component, and filling medium.

One of the principal problems in the development of acceptable hermetically sealed units has been the provision of satisfactory lead bushings at reasonable cost. First to be used were the rubber-sealed types. These seals were satisfactory both mechanically and electrically when first installed, but aging of the rubber effectively destroyed the sealing after a year or two.[5,6] Another objection to these bushings was the large number of parts which increased cost and assembly time. Next came solder-seal glass bushings. These bushings have a metallic glaze fired directly onto the glass so that they can be soldered to the can. Instead of soldering directly to the glass, a metal rim may be soldered first to the bushing.

From the viewpoint of high voltage and mechanical strength, ceramic-to-metal seals are the most useful hermetic seals. Ceramic has better dielectric characteristics than glass and readily lends itself to the petticoat design, thereby obtaining increased leakage and flashover protection. Moreover, ceramic has greater mechanical strength than a comparative glass structure. Bonding between metal and ceramic is performed by first coating the ceramic with gold, silver, platinum, or other metallic paint combined with a glaze. In firing, the metal is reduced to its pure state and forms a conductive coating on the ceramic. This ceramic then is joined with the metal by interposing a suitable brazing alloy wire between the ceramic and the metal and heating this assembly at 900 to 1,000 degrees centigrade in a protective atmosphere. The rather involved and expensive

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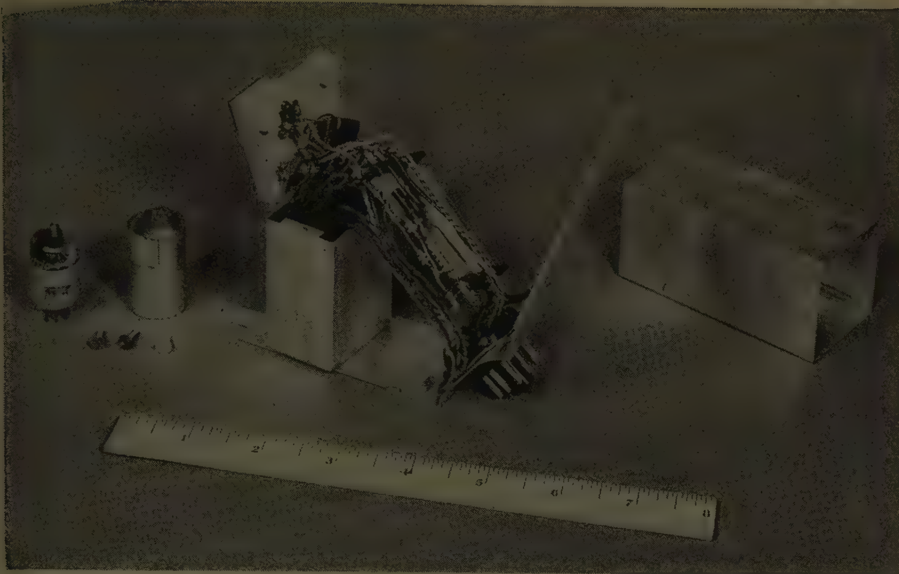


Courtesy Bell Telephone Laboratories

Figure 2. Telephone voice-frequency amplifier, chassis unfolded. This plug-in unit, although not hermetically sealed, shows construction readily employable for sealing

Courtesy Automatic Electric and Manufacturing Co.

Figure 3. Typical hermetically sealed relay plug-in-type construction

manufacturing procedure restricts the use of these bushings to operating potentials above 1,000 volts.

By far the greatest number of hermetically sealed components are equipped with glass-to-metal seals of the "hard"-glass type. The glass is of the pyrex type and is joined with the well-known Fe-Ni-Co sealing metal commonly known under the trade name of Kovar or Fernico. These seals are inexpensive and embody good thermal shock resistance. They are used for operating voltages up to 1,000 volts as single or multiterminal headers. Figure 1 shows a representative selection of multiterminal headers consisting of a metal grommet and an inner dish-like glass portion. Single lead-ins protrude through the glass dish, being spaced and insulated from adjacent lead-ins and from the common metal grommet. The periphery of the grommet is soldered to the metal enclosure which surrounds the hermetically sealed component. Such seals are available in great variety, ranging from single pin terminal to 14-pin terminals with bent, looped, flattened, and pierced pin construction, or for plugging directly into a receptacle such as octal base. Color coding of all individual pins, or for starting purposes around a single pin, is also available.[8]

All terminals are usually hot tin dipped with tin-lead solder (60/40, melting point 360 degrees Fahrenheit, tin bath temperature 525 degrees Fahrenheit) to facilitate the soldering of connections. Optional copper plating or gold flashing presents no difficulty. In order to improve the electrical surface resistance when exposed to high humidity or salt spray conditions, the insulating portion of the seals may be coated with a thin layer of silicone grease. Soldering should be done with a rosin-core nonacid flux.

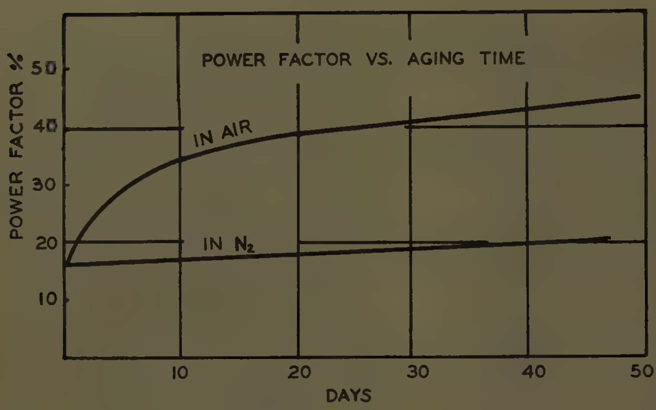
Latest material to be used as a sealing material is "Kel-F," a trifluorochloroethylene thermoplastic resin. Multielectrode terminal headers have been made for hermetic component with operating temperature range from −195.8 to +200 degrees centigrade, and operating potential of 3,000 volts peak at sea level. This nonhygroscopic material has excellent dielectric characteristics in moist atmospheres.

In general, any electrical component can be sealed hermetically although certain modifications may be required or at least are desirable (see Figures 2 and 3). The medium that surrounds the active circuit component within the hermetic enclosure may be vacuum, oil, or gas. Probably the most obvious circuit element surrounded by vacuum is the electron-tube assembly. Other equipment utilizing vacuum are vacuum capacitors, high-vacuum switches, and components of tuned circuits. Examples of oil-filled enclosures are transformers and chokes.[7–9] Although oil has very good dielectric properties and quite good thermal conductivity, its chief disadvantages lie in the fact that its thermal expansion is large, thus necessitating "breathing" provisions, and the maximum and minimum operating temperatures are limited. Hence, for the great majority of sealed components, gas is the medium surrounding the circuit element. In many applications, gas performs a twofold function; namely, (1) cooling of the device and (2) quenching of the arc (relays, vibrators, and so forth).

Gases commonly used in connection with sealed components are dry air, nitrogen, helium, and hydrogen, Table I.[10] All these gases are noncorrosive and substantially inert. Hydrogen is used only in special cases where extremely good cooling and/or rapid arc quenching is required. Hydrogen gas has over six times higher thermal conductivity than air and its over-all heat transfer performance is 50 per cent better than that of air. In view of its explosive nature when mixed with the critical amount of

Table I. Cooling Properties of Gases[10]

Characteristics	Air	N_2	He	H_2
Thermal conductivity	1	1.08	6.40	6.69
Density	1	0.966	0.138	0.07
Specific heat (constant pressure)	1	1.046	5.25	14.35
Heat capacity	1	1.02	0.72	0.996
Heat transfer	1	1.03	1.18	1.51



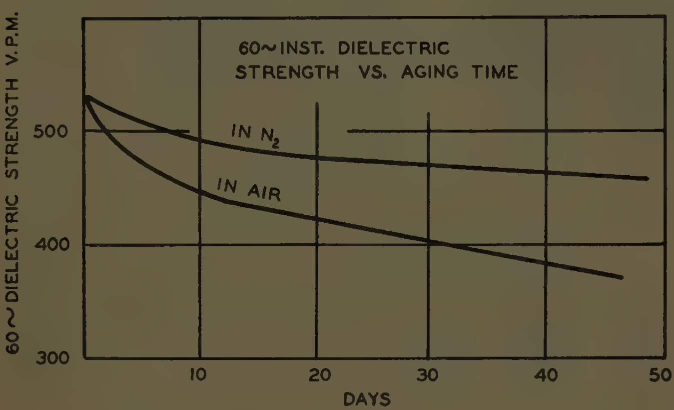


Figure 4.[11] Comparative aging of silicone-treated asbestos paper in air and nitrogen for three 0.004-inch silicone-treated asbestos papers aged at 349 degrees centigrade

air,* hydrogen presents certain dangers in the manufacture, use, destruction, or leak of the hermetic seal enclosure; hence its application is limited. It is confined mainly to relay contacts which are enclosed in a small hermetically sealed capsule or heavily loaded components that require extremely good cooling.

Of all rare gases (helium, neon, argon, krypton, xenon) helium has the highest thermal conductivity and an overall heat transfer performance 20 per cent above that of air. It is used, therefore, where good heat transfer from the circuit element to the can enclosure is necessary or desired. The price of helium has dropped in recent years, thus making this filling economically feasible.

In the case of hermetically sealed relays, especially power relays, the gas is called upon to have definite properties, namely, high sparking potential or arc suppression and high rate of heat transfer. Furthermore, when heavy arcing is encountered, the danger of chemical instability and absorption on the surfaces is increased. Certain manufacturers employ a mixture of nitrogen and helium gas. Helium, although of superior heat transfer performance, lowers the sparking potential, while nitrogen has a higher sparking potential but a lower heat transfer performance. By employing a mixture of these two gases a certain compromise can be reached.

* At atmospheric pressure, explosive mixture is 4.1 to 74.2 per cent by volume of hydrogen in air.

Nitrogen and dry air are, of course, the least expensive gas fillings. The air may be passed through conventional dryers as it has been found that a relative humidity of six per cent, measured at 55 degrees centigrade, results in a satisfactory operation of most electronic equipment, as far as condensed moisture is concerned, when the equipment is operated at temperatures as low as −51 degrees centigrade.[6]

Recently reported tests on the comparative aging effects of common class-*H* insulating materials in both nitrogen and air indicate that nitrogen has a marked beneficial effect.[11] Samples were composed of bare rectangular copper magnet wire separated by three thicknesses of 0.004-inch silicone-treated asbestos paper, aged at 660 degrees Fahrenheit (349 degrees centigrade). At the end of 45 days, a decrease of 60-cycle dielectric strength of only 14.5 per cent was shown in the nitrogen atmosphere as compared with a 31-per cent decrease in air (see Figure 4).[11] The power factor rose 25 per cent when samples were aged in nitrogen, as contrasted with 200 per cent in air. Temperatures as high as this greatly accelerate aging and are not ordinarily encountered.

Most of the cans used for hermetic sealing are deep-drawn steel simply because this is the cheapest material and because steel can be soldered readily by induction heating. Aluminum, brass, and zinc also have been used. The surface finish is generally tin or cadmium plating to facilitate later assembling. The cans may be of cylindrical or rectangular shape with large radii in the corners for structural strength.

Prior to filling, the entire assembly is connected to a high-vacuum pump and evacuated to a few microns' pressure. This insures that all traces of moisture and gas are removed. It is advisable to apply moderate heat to the container, 60 to 80 degrees centigrade, for about 30 minutes (infrared heating bulbs) to expel residual gases and moisture which are adsorbed to the walls. The container then is purged several times with dry nitrogen gas and again pumped down. As a next step it is filled with the selected gas medium to at least one atmosphere pressure (14.7 pounds per square inch). The usual pressure is 20 to 25 pounds per square inch. The evacuation tube finally is pinched off and thereby sealed.

Tests for tightness can be performed in many ways. Some manufacturers use the ultrasensitive mass spectrometer before and after final seal-off. The mass spectrometer is expensive and requires a skilled operator but can discover a leakage of only 0.01 micron per cubic foot of inert gas per hour. Other manufacturers specify leakage test by immersion of the can in pure water at 200 degrees Fahrenheit after having been stored in cold water for several hours. If there is a leak, bubbles will show. A still further test consists of placing the gas-filled assembly in a vacuum chamber and applying the full pressure differential (20 to 25 pounds per square inch) across the casing and seams. What constitutes a leak and how long the seal should hold still has not become a matter of specification.

ADVANTAGES AND DISADVANTAGES

THE HERMETICALLY sealed components are protected from adverse atmospheric and environmental influences; see Table II. Further, there can be no tamper-

Table II. Advantages and Disadvantages of Hermetically Sealed Components

Advantages	Disadvantages
Atmospheric Protection: Moisture and high humidity; Ice; Fungus growth; Salt air and spray	**Higher Initial Cost:** Better component; Terminal seal and can; Processing
Environmental Protection: Dirt; Dust; Sand; Corrosive fumes; Explosive fumes	**Increased Weight:** Especially small components; **More Difficult Heat Dissipation:** Resistors; Tubes
Human Protection: No tampering; No servicing; Minimum maintenance	**Field Operation:** No adjustment possible
Longer Life: Insulation deterioration slowed; Contact wear reduced; Arc extinguishing properties of gas	No replacement of individual components in larger units

ing by unauthorized or inexperienced personnel. The servicing and maintenance problem is reduced to a minimum. The circuit element is either good or bad. The servicing function, therefore, consists of an exchanging of factory-sealed and -adjusted components. The life of contacts and insulation is materially lengthened, sometimes by as much as a factor of five due to the absence of oxidation and reduced sparking. The gas filling prevents oxidation of lubricants in moving assemblies.

On the debit side there are several considerations, the foremost being the increased initial cost of hermetically sealed components. A hermetically sealed relay costs twice the price of an unsealed one. The reason is threefold.

The quality of the component enclosed must be good; there is no quick fixing, repairing, or exchanging of spring, contacts, and other active parts. The insulation must be better than usual, especially free of alcoholic base solvents and plasticizers. Such insulating materials, being of organic nature, have a very high vapor pressure with the result of contaminating the inert-gas filling by oxygen and combinations of carbon, hydrogen, and oxygen. Inert insulating materials, glass, glass fibers, fluorocarbon resins, and silicon compounds, are more expensive but can operate at higher temperatures. There are the additional costs of terminal seals and processing. In small components (relays, resistors, and so forth) the added enclosure represents weight. With high-power resistors, vacuum tubes, and so forth, the heat dissipation becomes more difficult. The use of sealed components permits very little field adjustment. This fact may be an asset or liability depending upon the individual installation and apparatus. Where several different components are sealed within a large enclosure—sealed amplifier—small short-life components cannot be replaced and the selection of first-quality components becomes doubly important.

In appraising the engineering and commercial considerations, it can be stated that a decrease in initial cost would make hermetically sealed components, especially those of the plug-in unit construction, very attractive and useful in industrial control.

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Two 40-Ton Electric Pusher Locomotives in Operation

These two 40-ton electric side-arm pusher locomotives were placed in service recently on the Baltimore and Ohio Railroad. These units operate on a special narrow-gauge track between standard railroad tracks. Power is supplied to each unit's two electric motors by a 250-volt third rail. Pincer-shaped arms, which spring out on both sides of the locomotive and hook onto the freight cars, enable the units to move two lines of freight cars simultaneously when necessary. By moving cars swiftly to the unloading area and back again, these side-pushers eliminate the tremendous amount of shuttling required with standard switchers. This installation makes possible the unloading of a 30,000-ton ore boat in 24 hours. The locomotives were built by the General Electric Company.

Resonant Grounding of American Power Systems

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THE LATEST AIEE Committee Report on Grounding Practices[1] indicated a trend toward increased use of Petersen coils in high-voltage power systems in this country. A study was undertaken to analyze the application of resonant grounding and questionnaires were sent to all operators using Petersen coils.

The number of ground-fault neutralizers in service during the 1921–49 period is given in Figure 1. This figure indicates a trend toward an increased use of extended time-rating equipment designed to operate on sustained as well as on transient (arcing) ground faults. The major field of application of resonant grounding is at voltages below 70 kv, although there are a few applications at 115 and 140 kv. Petersen coils are used, among others, in seven 69-kv systems and in 26 systems at 34.5 kv. A voltage of 115 kv seems to be a borderline case economically, unless all the advantages of solid neutral grounding are realized so that high-voltage equipment with reduced insulation (92-kv class) can be used throughout the system.

Of all systems now resonantly grounded, only 48 per cent were new systems or ungrounded (delta) systems previous to the installation of Petersen coils. Of the remaining 52 per cent, 67 per cent were solidly grounded and the change to resonant grounding brought a considerable reduction both of line tripouts and of disconnected mile-hours per year.

Answers were received from 56 systems, of which 23 had

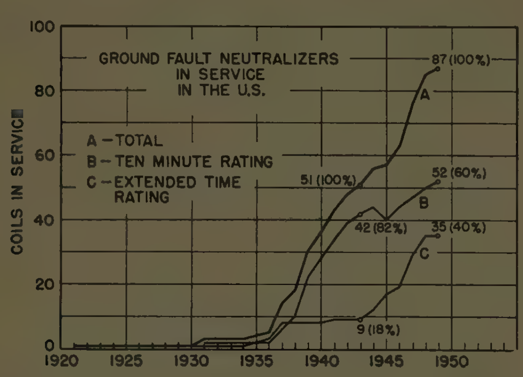

Figure 1. Ground-fault neutralizers in service

coils designed to operate permanently, and Figure 2 shows that good use was made of this design. The duration of operation with sustained ground faults varies from a maximum of two hours in a 69-kv system to several days in a 2.4-kv system. This seems to indicate that many operators do not hesitate to continue operation in spite of a permanent ground fault on one phase of the system and, therefore, with full line voltage to ground on the other two phases. Furthermore, 32 per cent of those using short-time (10 minute) rating coils indicated that they would now install extended time-rating coils in order to have the additional advantages of undisturbed operation during sustained ground faults.

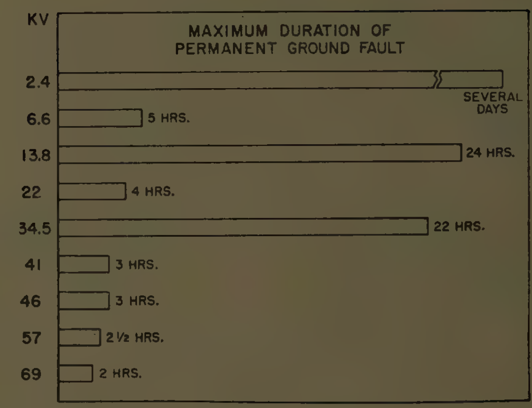

Figure 2. Maximum duration of sustained ground faults classified by voltage

The effectiveness of resonant grounding in out-of-resonance conditions is well recognized. Unlike a radio, the operation of Petersen coils is still very satisfactory when the adjustment is ±20 per cent or even more off resonance. Accordingly, as many as 27 per cent of all systems keep the setting on the same tap at all times, 29 per cent make tap changes from one to ten times per year, and only 19 per cent operate the changer more than ten times per year.

Most Petersen coils (70 per cent) are tapped, single-phase, iron-core reactors connected between the neutral of a power transformer and ground. Only 30 per cent were built as 3-phase equipment and are either a grounding transformer with the Petersen coil in the same tank or a grounding transformer with its neutral grounded and a tapped reactor inserted in the open delta of the three secondary windings. It is noteworthy that the total system mileage does not limit the application of resonant grounding, since the largest 34.5-kv system in this country is so grounded. The total mileage of this 34.5-kv system is now 1,600 miles of overhead lines.

It is clearly indicated that experience with resonant grounding has been very satisfactory. Not only is the grounding method here to stay, but its use will increase and in future installations preference will be given to equipment designed for extended time rating since operation on sustained ground faults brings additional advantages.

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Transient Response of Magnetic Amplifiers

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THE TRANSIENT RESPONSE of magnetic amplifiers with cores of gradually varying incremental per-neability can be analyzed with methods already applied n previous articles. For this, the alternating component of core fluxes is assumed to vary sinusoidally and the normal nagnetization curve is approximated by a hyperbolic ine function of the type $H = U \sinh uB$. A straightforward ntegration of the differential equations of the control ircuits for a step change of the signal voltage becomes hereby possible, at least for "slow" transients lasting over a few cycles of the a-c source frequency, and curves repre-enting the output current (rms or rectified average) during the transient can be calculated.

Results are presented in a general dimensionless form in Figure 1 for amplifier circuits without feedback. The ordinates represent dimensionless outputs $\mathfrak{F}_{Lt}/m$ where $\mathfrak{F}_{Lt} = NI_{Lt}/lU$, where N is the number of turns of the output winding on one core for parallel-connected amplifier or twice this number for series-connected output windings, I_{Lt} is the rectified average of output current at the time t, l is the length of the magnetic circuit in any consistent system of units, and m is defined as the series of modified Bessel functions of the first kind

$$m = 2[\mathcal{J}_1(uB_m) - 1/3\ \mathcal{J}_3(uB_m) + 1/5\ \mathcal{J}_5(uB_m)\ldots]$$

where B_m is the crest of the alternating component of core flux density. In terms of the crest E_{max} of the alternating voltage at the output terminals, of its frequency f, and of the core cross section A, it is $B_{max} = E_{max}/N2\pi fA$.

The abscissae are times divided by a time scale factor

$$\tau = (A/Uuln) \sum_{\nu} N_\nu^2/R_\nu$$

where $n = \mathcal{J}_0(uB_m)$ = modified Bessel function of the first kind and zero order and the summation of "turn square per ohm" is extended to include all circuits in which unidirectional currents are induced during the transient. (For example, in a series-connected amplifier with a signal circuit of N_1 turns per core and $2R_1$ total circuit resistance and with a bias circuit of N_b turns per core and $2R_b$ total circuit resistance

$$\sum_{\nu} N_\nu^2/R_\nu = N_1^2/R_1 + N_b^2/R_b$$

An additional term N_2^2/R_2 appears in the summation if the output windings with N_2 turns per core and resistance R_2 per winding are parallel connected.)

The various curves plotted are identified by steady-state final values known from steady-state considerations. The origin of time, for any given transient, is chosen so as to coincide with the abscissa corresponding to the assigned initial value of $\mathfrak{F}_{Lt}/m$.

The curves given in Figure 1 are of two kinds: some show a continuous decay of $\mathfrak{F}_{Lt}/m$ and apply for step reductions of the signal; other curves show a decay and a subsequent rise and apply for reversals of signal or also, in the portion of increasing $\mathfrak{F}_{Lt}/m$, for rising transients, characterized by a continuous increase of the absolute value of d-c component of flux density. The curves presented have been obtained under the assumption of a constant B_{max}. The presence of loads in the output circuit actually may cause variations of B_{max} during the transient. A good approximation is obtained in these cases by evaluating m and τ on the basis of the highest of the values of B_{max} during the transient.

Digest of paper 51-175, "The Transient Response of Magnetic Amplifiers—Cases of Negligible Commutation," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Madison, Wis., May 17–19, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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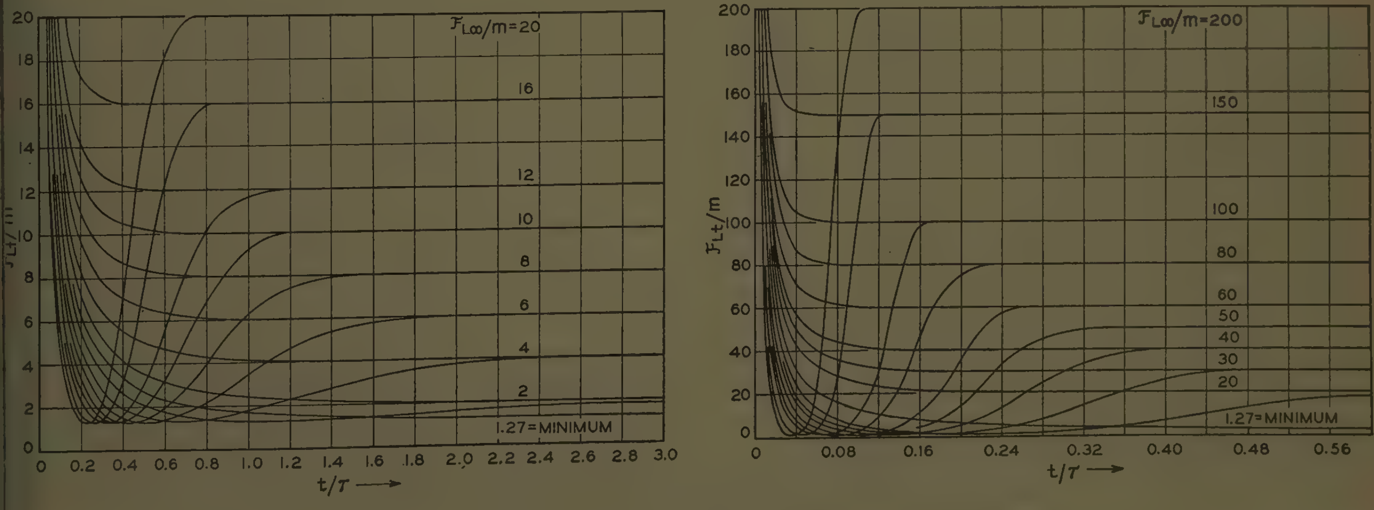

Figure 1. Transient response of magnetic amplifiers without feedback

A Broad-Band Transcontinental Radio Relay System

T. J. GRIESER A. C. PETERSON

Spanning the continent from coast to coast, this microwave relay system provides six channels, each of which can carry one television circuit or hundreds of telephone circuits. Some features of this vast network are described.

THE BELL SYSTEM'S rapidly expanding network of radio relay stations started to grow in 1947 when the 8-hop 220-mile system between New York and Boston was installed. This system was placed in commercial service in January 1948. The first system to span the continent is scheduled for service in August of this year. A portion of this communication artery has been in commercial use since September 1, 1950, when the American Telephone and Telegraph Company opened service between New York and Chicago. Shortly thereafter, the system was extended to Omaha, a total distance of 1,300 miles. On the west coast a link between Los Angeles and San Francisco was opened for service last September. Systems from New York to Washington and from Dayton to Indianapolis also were opened in September.

As a result of the successful experience with the 4,000-megacycle system installed for the New York to Boston trial, known as the *TD-X* system, design objectives were formulated for an improved system also to operate in the 4,000-megacycle frequency range but capable of being extended to 4,000 miles and providing six broad-band channels in each direction. Each channel was to carry hundreds of telephone circuits, or one television circuit. Because of the economic necessity of operating most of the repeater stations unattended, careful consideration was given to the stability and reliability of the radio equipment and power plants and to the automatic alarm and control features. This facility is known as the *TD-2* Radio Relay System.

LAYOUT OF THE SYSTEM

THE SELECTION and development of repeater station sites is a function of the operating telephone companies. The route selected for the transcontinental system is shown in Figure 1. As will be noted, it follows closely the main transportation and communication routes between New York and Oakland, Calif., passing through or close to Philadelphia, Pittsburgh, Cleveland, Chicago, Des Moines, Omaha, Denver, and Salt Lake City. It is comprised of 106 repeater stations, including the terminals. Seventeen of these are main repeater or terminal stations, a number of which have complete or partial attendance, while 89 are auxiliary repeater stations that are normally unattended. Main repeater stations are provided with facilities for switching and patching at intermediate frequencies. This permits the removal of a channel for maintenance purposes or for its replacement by a spare channel in case of failure.

In selecting repeater sites problems frequently arise because of the desire to utilize natural ground elevations to assist in obtaining line-of-sight paths between antennas as opposed to the need for accessibility for maintenance as well as for the availability and reliability of commercial power sources. By taking advantage of high natural elevations in hilly and mountainous country it is usually only necessary to elevate the antennas above the local trees, while in flat country it is necessary to locate the antennas at a height of 100 to 200 feet to obtain line-of-sight paths and reasonable spacing of repeater stations. The average repeater spacing for the transcontinental system is about 28 miles with the individual hops ranging between 9.3 and 50.1 miles in length. The signal fading margin is improved if the line-of-sight path is well above the intermediate obstructions. As a general rule an attempt is made to obtain first-Fresnel-zone clearance.[1]

Prospective sites may be selected by a study of topographical maps. In many cases, however, the maps are not sufficiently accurate to permit final decisions to be made and it is therefore necessary to make actual attenuation measurements over the path. For this purpose, the portable tower shown in Figure 2 was designed. This tower is made up of 8-foot portable sections and may be erected to a height of 200 feet. It is easily raised from the ground.[2] The 57-inch parabolic reflector test antenna is mounted on a carriage which can be run up and down the side of the tower. The signal attenuation between towers located at adjacent sites is measured for various antenna elevations and from these measurements information is obtained on which to base the height of the permanent towers. Most of the paths are tested in this manner.

Another factor which must be considered in laying out a radio relay route is that of overreach interference. The frequency allocation plan for the 12 broad-band channels of the *TD-2* system is illustrated in Figure 3. Two frequencies 40 megacycles apart are assigned to each channel and these are used in alternate repeater sections. Thus a

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Figure 1. Route of the transcontinental radio relay system. It has 106 repeater stations, of which 17 are terminal stations

hannel frequency band transmitted from a station in pposite directions is always 40 megacycles removed from he frequency band received at that station from opposite irections. This is done to prevent noise and interference eedback around the repeater. However, since the fre- uency received at a particular repeater station is also received at every alternate repeater along the system, there is the possibility of overreach interference and this factor must be considered in selecting sites. If a particular transmitting antenna is pointed at or near the receiving antenna in the second adjacent hop, there may be overreach interference at times unless a suitable physical barrier exists between

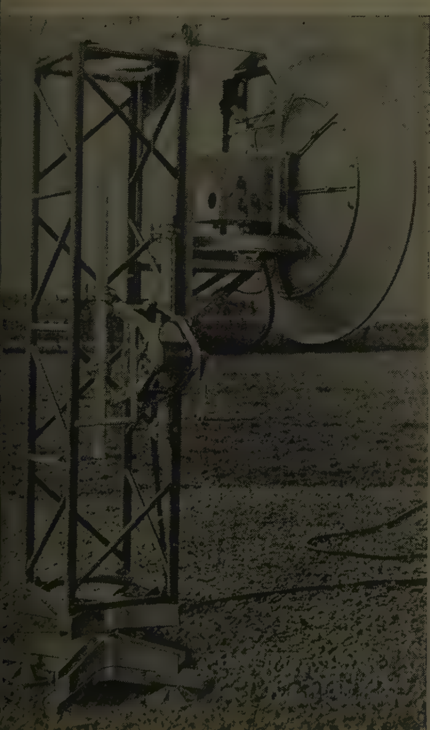

Figure 2 (left). Portable tower and antenna for measuring path loss

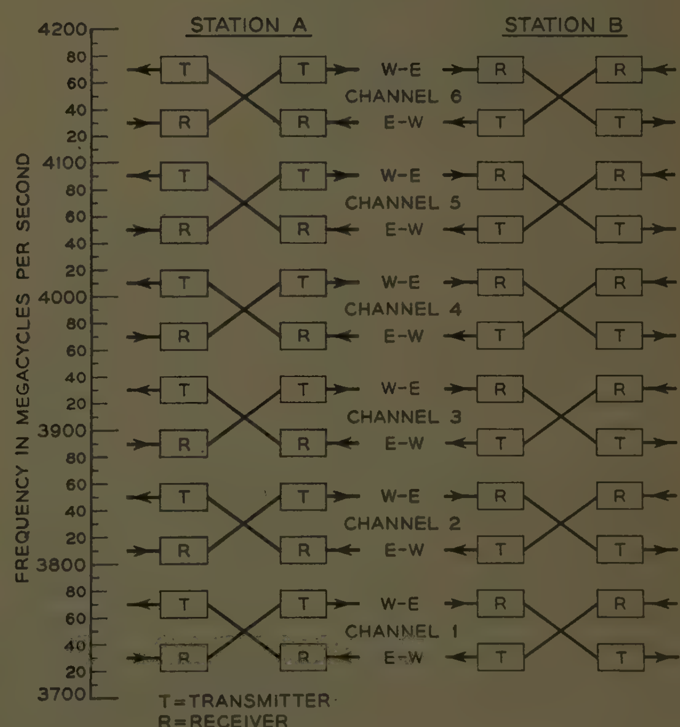

Figure 3 (right). Frequency allocation plan between two stations

Figure 4. A 103-foot reinforced concrete tower of the type used between New York and Des Moines

Figure 5. An open steel framework type tower. The shack houses the radio equipment

the two stations. If there is insufficient barrier, the sites must be selected in such a manner that the total antenna directional discrimination is of the order of 50 decibels. The general rule which has been followed in laying out *TD-2* system routes is to select sites which result in these antennas being oriented at least 5 degrees away from a line joining the two antennas.

TOWERS

THREE GENERAL types of tower and housing construction are used on the transcontinental system. The type selected depends upon a number of considerations such as availability of materials, natural ground elevations, permissible waveguide loss, possible need for future expansion, and upon economics. The towers in the section of the system between New York and Des Moines are all of reinforced concrete construction and vary in height from 65 to 200 feet. In rugged country like Pennsylvania the towers are just high enough to permit the radio beam to clear the trees near the stations; in flat country the curvature of the earth as well as the trees must be considered, and the tower height is therefore increased to provide spans of reasonable length. Figure 4 shows a 103-foot tower in Pennsylvania. The lower deck on the top of the tower is intended for antennas to be used on spur routes, or for other system growth.

The towers between Des Moines and Denver are of open steel framework construction with the radio equipment housed either in an enclosure part way up the tower or in a small building on the ground. Such a tower is shown in Figure 5. In the mountainous section of the far west the equipment is generally housed in a single-story building with the horn antennas mounted on the roof as shown in Figure 6.

ANTENNAS AND WAVEGUIDES

THE ANTENNAS used in this system are of the delay lens type.[3] They are designed to produce a plane wavefront by delaying the waves near the center of the antenna relative to those near the edges. The front opening of these antennas is about 10 feet square. The average gain over the 500-megacycle band relative to an isotropic radiator is 39 decibels and the major lobe of the directional pattern is less than 2 degrees wide at the half-power points. The maximum response in the direction opposite to that of desired transmission is in the order of 68 decibels down from the maximum forward response, over an angle of ± 40 degrees.

The antennas are connected to the radio equipment by means of rectangular brass waveguides having approximate outside dimensions of $1^{1}/_{4}$ by $2^{1}/_{2}$ inches. The transmission loss through this waveguide at 4,000 megacycles

Figure 6. Repeater station of the type used in mountainous terrain

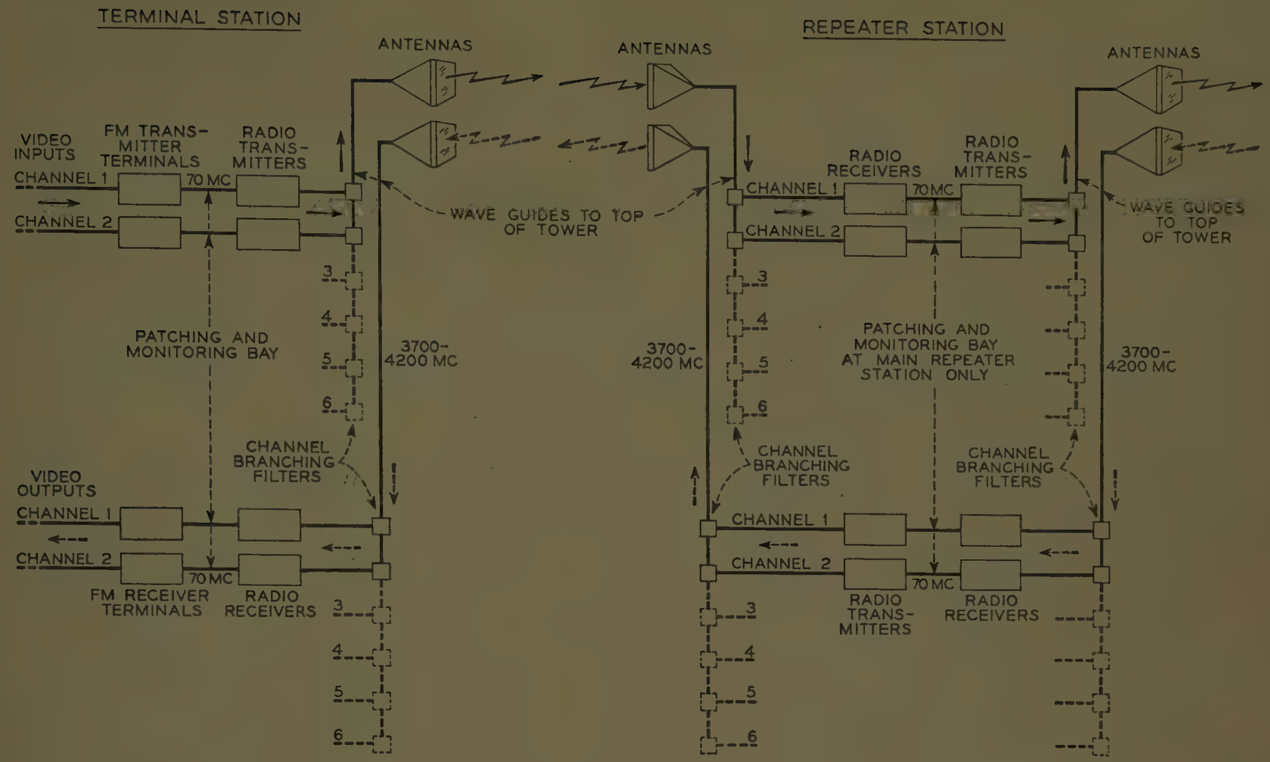

Figure 7. Schematic block diagram of a terminal and repeater station

is about 1.5 decibels per 100 feet. Because of this loss it is desirable to keep the waveguide runs as short as possible consistent with the other factors which must be considered in the design of towers and equipment housing.

DESCRIPTION OF TERMINALS AND REPEATERS

THE *TD-2* radio relay system provides 12 broad-band channels, six in each direction of transmission. It utilizes frequency modulation and operates in the 3,700- to 4,200-megacycle common carrier band. A schematic block diagram of a terminal and repeater is shown in Figure 7. The input to the frequency modulation transmitting terminal may be either a television signal, or the signal resulting from the combination of hundreds of telephone conversations derived from the same equipment that is used in stacking telephone channels for transmission over coaxial cables.[4] The 70-megacycle frequency-modulated output of the transmitting terminal is fed to the radio transmitter where it is heterodyned to the microwave frequency range and amplified to a power level of about 1/2 watt. This signal then is fed to the appropriate channel branching filter. The combined output of the several branching filters is in turn connected to the transmitting antenna by means of waveguide.

After traversing the radio path to the adjacent repeater station the microwave energy is intercepted by the receiving antenna and fed through the waveguide transmission line to receiver branching filters. These filters are similar to those used on the output of the transmitters. After being selected by its appropriate filter each channel is converted to an intermediate frequency of 70 megacycles and amplified in the radio receiver. At auxiliary repeater stations the output of the receiver is connected directly to the transmitter while at main stations the connection is made through intermediate-frequency patching and switching circuits. The frequency of the signal transmitted by the repeater is shifted 40 megacycles from that received.

Under nonfading conditions the radio path loss over the average 28-mile hop is about 138 decibels. The total waveguide loss plus filter loss per repeater section averages 5 decibels. Since the power gain of the transmitting and receiving antennas totals about 78 decibels, the net over-all gain of the repeater under these conditions must be 65 decibels. In the receiver an automatic gain control circuit with a nominal range of about 30 decibels is used to keep the output power of the transmitter constant by compensating for fading losses and vacuum-tube aging. Since fading seldom occurs simultaneously in adjacent sections of a system, fades as deep as 40 decibels in one section can be tolerated, the extra gain being provided by the next repeater. The frequency modulation quieting characteristic begins to break on a 40-decibel fade.

SWITCHING

BY STANDARDIZING on a common interconnecting or intermediate frequency throughout the system, very flexible arrangements are made possible. In a long system used for the transmission of telephone messages it is, of course, necessary to add and drop blocks of channels at various places. This will usually be done at main stations in or near the larger cities. For this purpose it is necessary to convert to the baseband frequency range and back to the intermediate frequency range by means of frequency modulation terminals which transmit and receive at the 70-megacycle interconnecting or intermediate frequency.

Another function performed at main repeater stations,

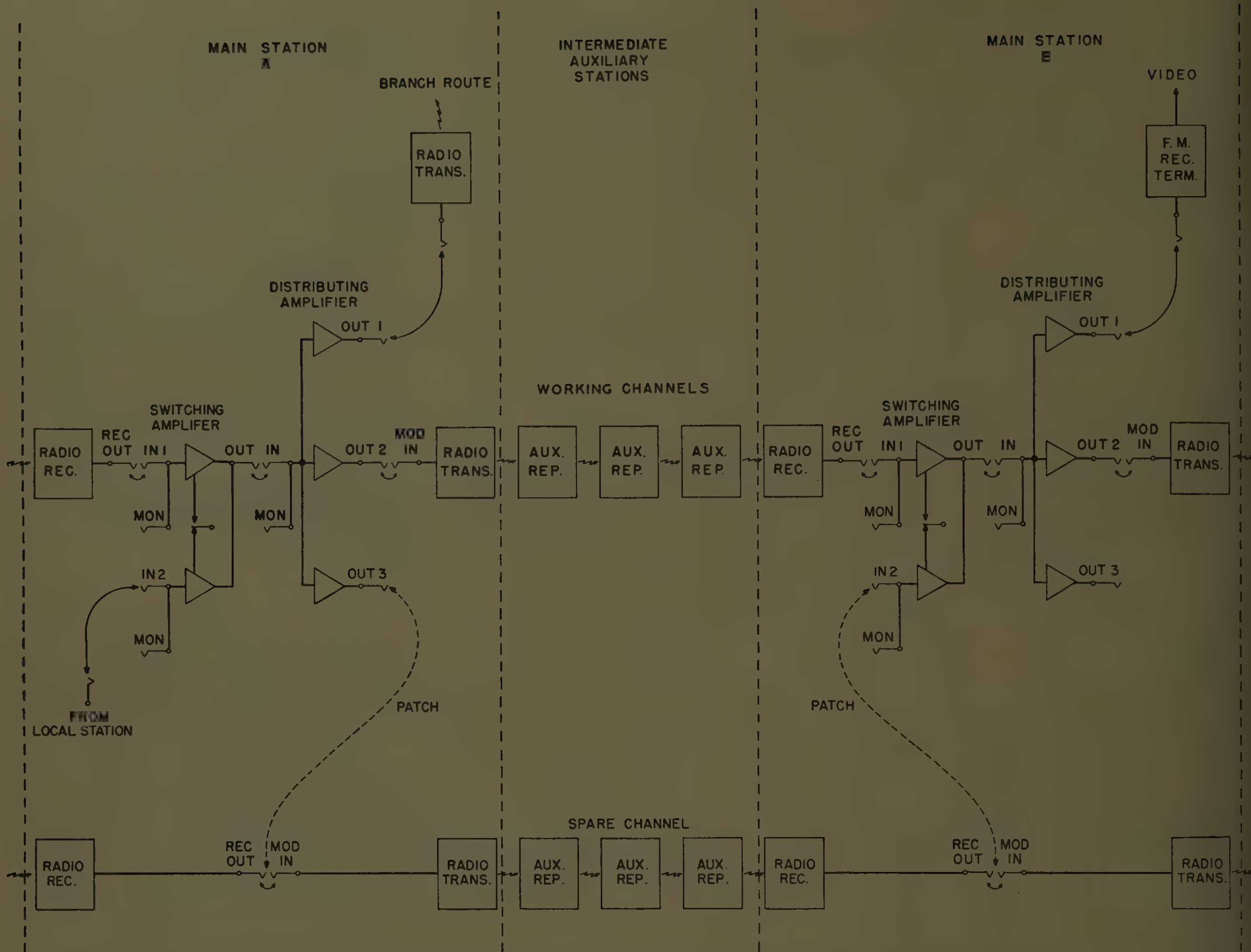

Figure 8. Intermediate-frequency switching and patching arrangements as used between two main stations

but without converting to baseband frequencies, is that of replacing one of the regular or working radio channels with the spare channel in case of trouble on a regular channel, or for routine maintenance purposes. Figure 8 represents a portion of the system between two main repeater stations, *A* and *B*. Assuming that routine maintenance work must be done at one of the intermediate auxiliary repeater stations and that the regular channel must be removed from service for this purpose, the maintenance man must obtain a release from the operating personnel at main station *A* before interrupting the channel. At this station there is a unity gain distributing amplifier operating at the 70-megacycle intermediate frequency which has one input and three outputs. One output feeds the regular channel and one of the others energizes the spare channel.

Main station *B* is equipped with a 70-megacycle unity gain switching amplifier. This device has two inputs and one output, with only one through path enabled at a time. When the attendant at station *B* is certain that the switching amplifier is connected to both the regular and spare channels, he operates the switch to the spare position, making the regular channel available at the intermediate repeater stations. The switch operates rapidly without any perceptible interruption of the channel. While not in use the spare channel must be energized by a signal to prevent low output alarm indications at the auxiliary stations.

The distributing amplifier is used also where it is desired to serve a television station from a drop on a through channel. One output of the amplifier feeds the through circuit while another feeds the local drop. This service may be provided either at video frequency, as shown at main station *B*, in which case a frequency modulation terminal receiver is required, or over a spur radio link, as shown at main station *A* where a radio transmitter is needed.

To feed the network from a local station the switching amplifier is used as indicated at main station *A*. One of the inputs is fed either by the output of a frequency modulation terminal transmitter handling the local program or by a radio link terminating at the 70-megacycle intermediate frequency. By operating the switch locally or remotely the pickup is fed to the network.

ALARM AND REMOTE CONTROL SYSTEM

The use of a specially designed alarm and control system, along with the extremely reliable power plant, makes it possible to operate the stations on an unattended basis. In most cases the alarms, remote controls, and maintenance talking circuits are handled by wire. The

wire facilities include an express order circuit which extends between principal terminal offices, a series of local order circuits, and an alarm circuit. The express order circuit appears at alarm centers, maintenance centers, and main stations; it does not appear at auxiliary stations. These have access to the local order circuits only. The alarms for a group of unattended stations appear at certain points designated alarm centers which may or may not be maintenance centers. Each repeater station in an alarm section is assigned an individual alarm frequency tone in the range between 1,100 and 2,100 cycles. The tones are sent on the alarm line as long as no alarms exist at the stations.

There are 42 possible alarm indications, such as station open door, high station temperature, failure of aircraft warning light, low repeater output, and so forth. If any of these conditions occurs at a station, or if trouble occurs in the alarm system itself, the distinctive tone for that station will be removed from the alarm line. This will operate a visual and audible alarm at the alarm center. Upon receipt of an alarm, the attendant at the alarm center sends out one of the ten possible coded orders on the local order circuit to the indicated station to scan the 42 possible alarms. The order is sent by modulating a 1,600-cycle carrier frequency with the proper combination of low frequency tones. The alarms are reported back to the alarm center by means of a synchronized pulse system using 700- and 900-cycle tones. Upon receipt of this alarm information the maintenance center will be notified of the kind of trouble and its location. This permits a decision to be made as to whether immediate attention is required or whether the matter can be delayed until a more convenient time. Other functions which may be performed over the remote control system include the operation of intermediate frequency switches and the starting and control of engine driven generators.

POWER SUPPLY

For this system as for other telephone transmission systems the power plant was designed for high reliability. The power is supplied to the equipment solely from storage batteries. The highest potential required is 250 volts. In addition to the 250-volt source, 12- and 130-volt supplies are also required. These are used to supply vacuum-tube heaters and anodes. Another power supply of 24 volts is required for alarm circuits, voice frequency amplifiers of the order circuit, talking battery, rectifier control circuits, and for other miscellaneous purposes. The batteries normally are floated on the line through regulated rectifiers operating from commercial 60-cycle power. Except for the 24-volt battery, multiple rectifiers are provided, so that when a working rectifier fails another automatically takes over.

Emergency power for the repeater stations is obtained from 20-kw and 30-kw gasoline engine driven generators. The 30-kw capacity is required only at main stations having a large number of branching channels. If a commercial power failure persists for more than about $2^1/_2$ minutes, the engine starts automatically and, after a 5-minute warm-up period, takes over the battery charging rectifier load. The batteries serve the dual purposes of supplying power to the equipment during this interval of about $7^1/_2$ minutes, and of carrying the load should the engine fail to start. In any case the alarm center is informed when the commercial power fails and if the engine does not start, the alarm center is also informed of this fact.

MAINTENANCE

The repeater stations are visited on a routine basis to do preventive maintenance work, and also whenever trouble arises. The maintenance personnel are generally stationed at maintenance centers located in telephone offices along the wire network. The radio system is usually only part of their responsibility. The repeater stations are provided only with the test equipment required to permit isolation of trouble. When a unit in trouble requires extensive tests or repair, a station spare is substituted and the faulty unit is returned to a maintenance center. These centers are equipped with more elaborate testing equipment than are the repeater stations, and the more complex repairs and adjustments are made there.

In addition to the numerous maintenance routines performed on the equipment and described in accompanying articles, there are a number of over-all system tests that are made on a regular basis. These include measurements of noise, gain-frequency characteristics, and distortion.

OVER-ALL TRANSMISSION

Transmission-wise the *TD-2* Transcontinental System is designed to meet Bell System toll standards. Since this system is subject to changes in noise resulting from the repeater gain changes associated with fading, the time distribution of noise impairments will be different than for wire circuits. In general, the most severe fading is apt to occur in the summer time during the late evening or early morning hours. Measurements to date indicate that the circuit noise will be well within the required limits except for a very small percentage of the time.

By means of envelope delay equalizer units at each repeater station and mop-up equalization at terminal stations, the modulation noise resulting from envelope delay distortion has been reduced to a value comparable with that for fluctuation noise. Modulation noise resulting from waveguide echoes is believed to be less than that caused by envelope delay distortion in other parts of the repeater.

The bandwidth of each radio channel is adequate to transmit several hundred telephone conversations or a standard television program. The distortion observed on a television test pattern sent over 4,000 miles of *TD-2* system, set up by looping at various points, was sufficiently low to be just barely perceptible to an experienced observer.

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A Recording Tachometer for Measuring Instantaneous Angular Speed Variations

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Combining desirable features of several instruments, this recording tachometer can measure speed variations in rotating shafts produced by gear, belt, chain, and other types of drives, and also determine resonant frequencies of rotating systems and measure torque pulsations.

THIS ultrasensitive recording tachometer measures both instantaneous and long-term speed variations of rotating shafts, rolls, and moving continuous webs. It will operate in a peripheral speed range of 5 to 120 feet per minute and resolve speed variations occurring at frequencies from 0 to 70 cycles per second. Sensitivity is adjustable in a range from 0.2 to 100 per cent speed variation for full-scale deflection. A resolution of 0.005 per cent speed variation is obtained with the instrument at maximum sensitivity.

Auxiliary equipment is used in the tachometer for static and dynamic calibration. A frequency analyzer also has been included for determining the frequencies present in the complex waveforms usually encountered. Vibration measuring equipment is used sometimes in conjunction with the tachometer to correlate results better. The equipment consists of a speed sensing unit $7^1/_2$ inches long by 3 inches square and the tachometer proper, which is housed in a portable cabinet 4 feet high by 20 inches square. The physical arrangement is shown in Figure 1.

Figure 1. The sensitive tachometer in its portable housing

A block diagram of the system is shown in Figure 2. The system is composed of a speed sensing unit for generating a frequency signal proportional to angular velocity; an a-c amplifier for amplifying the output signal from the frequency generator; a frequency meter for converting the frequency signal to a direct voltage signal; a bucking circuit for cancelling the major voltage signal, thus leaving only plus or minus variations in voltage; a low-pass filter for eliminating voltages at frequencies above 70 cycles; a d-c amplifier for amplifying the plus or minus variations in voltage; and a direct inking oscillograph recorder capable of recording voltage variations at frequencies up to 100 cycles.

Figure 2 also shows an audio oscillator equipped with an adjustable modulator which is used in place of the speed sensing unit in making static and dynamic calibration checks of the system response. A displacement type vibration pickup device and associated amplifier is shown feeding into a second channel of the recorder. A frequency analyzer and associated low-frequency amplifier are shown connected to the output of the low-pass filter.

The speed sensing unit is a low-inertia photoelectric frequency generator producing 6,000 cycles per revolution of its shaft which is driven at the point being measured by means of a friction drive wheel. A cross section through this signal generator is shown in Figure 3.

The frequency signal is produced by a photographically reproduced shutter disc having 6,000 equally spaced radial lines generated upon it. Conventional projection optics are used to image the disc on a stationary grid which is a copy of a sector of the disc. The light striking the cathode of the phototube thus is shuttered alternately as the disc rotates and produces a frequency signal proportional to angular velocity of the disc.

A cathode follower preamplifier stage is incorporated in the speed sensing unit to reduce the output impedance

Essentially full text of paper 51-238, "A Tachometer for Measurement of Instantaneous Variations in Angular Velocity," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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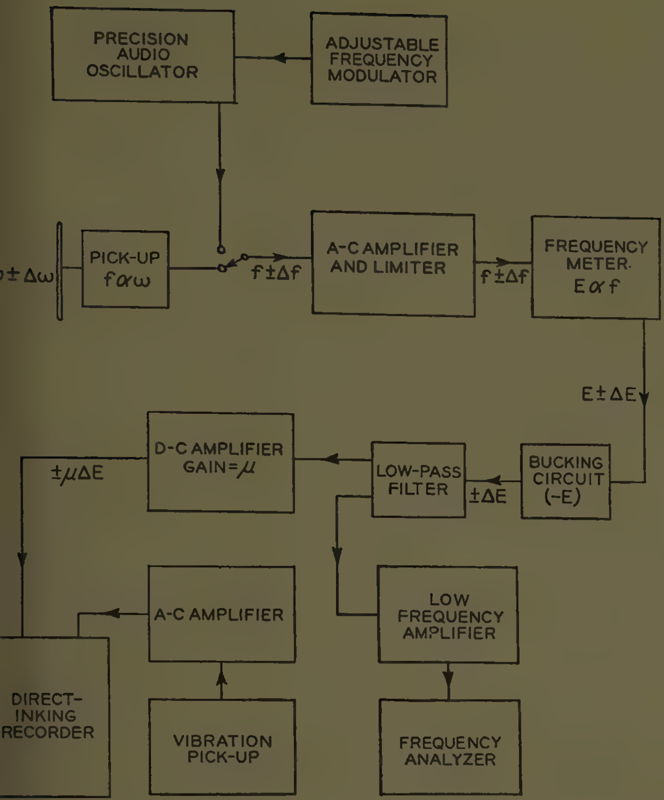


Figure 2. Block diagram of the tachometer circuit

or transmission of the signal to the tachometer. The peed sensing unit is connected to the tachometer through shielded cable 25 feet long.

The a-c amplifier and limiter has been designed to iminate the effects of a nonuniform waveshape generated y the speed sensing unit. In general, the amplifier raises ne voltage of the signal considerably beyond that re- uired to drive the frequency converter and the limiter ips off the tops of the waves, thus eliminating the dis- rtion and leaving a square wave signal of good uniformity.

The a-c amplifier consists of a 2-stage capacitance- oupled system with a fixed gain of 6,000. The limiter onsists of a twin diode clipper stage t to pass a square wave of ±3 olts amplitude.

The frequency converter is a fre- uency meter having a range of 0 50,000 cycles. Basically this nit converts the carrier frequency a series of pulses of constant nplitude and polarity which then e applied to an inductance-capac- ance filter. The relationship be- veen frequency and current rough the inductance of this filter linear over the range used. A unt diode rectifier is capacitance- upled to the filter with a result- t direct voltage developed across e output terminals of 5 volts at 0 cycles and 100 volts at 10,000 cles.

A multisection resistance-capacitance filter is connected to the output of the frequency converter to suppress any remaining trace of the carrier frequency from the d-c voltage. Since the lowest carrier frequency at which the instrument is applied is 500 cycles, the filter has been designed for cutoff at that frequency. It should be noted that this filter represents a compromise from the standpoint that frequencies considerably below 70 cycles are at- tenuated to some degree. An inductance-capacitance filter would have a much sharper cutoff frequency but would involve undesirable 60-cycle stray field pickup from the power circuits which would interfere with the readings of the instrument.

A direct voltage bucking circuit is used to cancel out the average voltage signal coming from the frequency converter through the low-pass filter, thus leaving only the plus or minus variations in voltage. Since this average voltage signal varies from 5 volts at a carrier frequency of 500 cycles to 100 volts at 10,000 cycles, the bucking circuit is made adjustable over this voltage range for matching to a specific signal.

The bucking circuit consists of a 10,000-ohm 10-turn helical potentiometer connected across a 135-volt radio-type B-battery. This combination is inserted in series with and opposed in polarity to the signal from the frequency converter.

A Brush d-c amplifier and dual channel electromagnetic direct inking oscillograph recorder are used to amplify and record the signal passed through the bucking circuit. The dynamic response of this system is practically flat from 0 to 100 cycles. Although the recorder alone has a resonant peak frequency at about 35 cycles and attenuates sharply at frequencies above 60 cycles, the amplifier employs feedback frequency compensation for both of these factors, thus resulting in a combined response generally flat out to 100 cycles.

The second channel of the recorder is provided to permit the simultaneous measurement of other dependent or influencing variables such as linear vibration, tension, voltage, and so forth. A suitable sensing element and

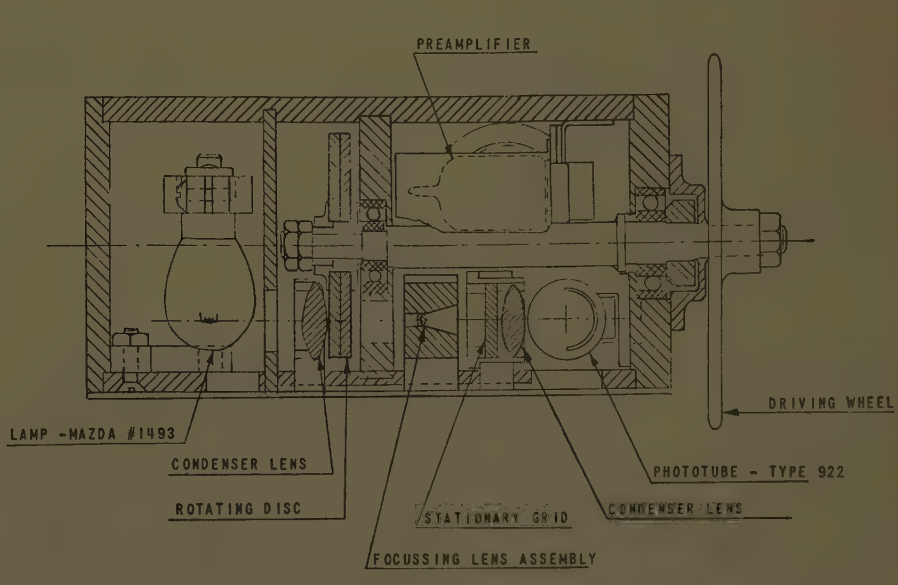


Figure 3. Section of the speed sensing unit showing light source and lenses

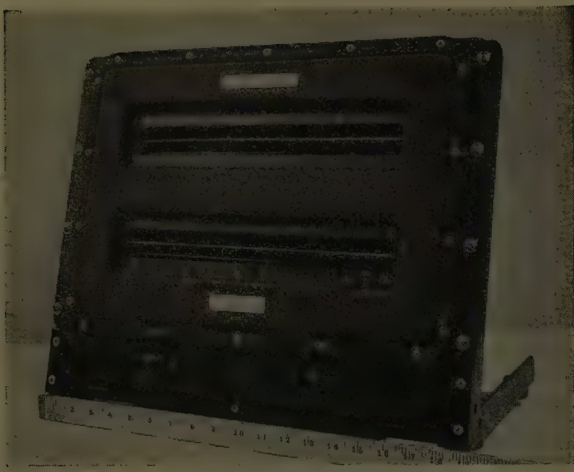


Figure 4. Panel of the vibrating-reed wave analyzer

Figure 5. Modulator equipment for the tachometer

amplifier is required for each particular case. The recorder deflection coil has a resistance of 1,500 ohms and requires a potential of 15 volts at 10 milliamperes for full scale deflection.

Because of the complex nature of the record frequently produced by the tachometer, a wave analyzer is provided to permit resolution of the complex waveform into its component frequencies. A Frahm-type directly indicating vibrating-reed unit has been selected for this purpose. The analyzer consists of 288 magnetically excited reeds covering a spectrum of $12^1/_4$ to 100 cycles. Figure 4 shows the arrangement of this analyzer.

The advantage of this unit over the scanning type lies in the fact that all of the tuned elements are energized continuously and several elements may respond simultaneously to frequencies present in the signal which correspond to the resonance frequency of these elements. A low-frequency amplifier having an impedance output characteristic to match that of the analyzer is used to feed the analyzer from the output of the direct voltage bucking circuit.

Equipment for calibration of over-all static and dynamic response of the tachometer is provided in the form of a beat-frequency oscillator and a modulator having an adjustable frequency characteristic in the range from 0 to 70 cycles. The beat-frequency oscillator is shown as part of the tachometer proper in Figure 1 and the modulator equipment is shown in Figure 5.

The modulator consists of a 12- to 75-micromicrofarad rotatable air-dielectric capacitor driven by an adjustable speed motor having a speed range from 0 to 70 revolutions per second. The motor and speed controller consist of a laboratory type d-c motor with thyratron field and armature control to obtain wide speed range.

The speed sensing unit is replaced by the combination of the oscillator and modulator in calibrating the tachometer response. The oscillator is tuned to produce a frequency signal duplicating that of the speed sensing unit for the particular speed in question. The modulator capacitor is connected into the oscillator tank circuit, and when rotated it produces a small increment variation in oscillator output frequency at a rate corresponding to the motor speed. Thus a signal that can be adjusted for both base speed (carrier frequency) and frequency of variation is produced for feeding into the tachometer. The over-all dynamic response of the tachometer system over a range of 0 to 70 cycles for carrier frequencies of 500, 1,000, 1,500, 5,000, and 10,000 cycles is shown in Figure 6. It is noted that the d-c amplifier feedback compensation is adjusted for optimum response at each carrier frequency.

Since linear vibration occurring between the pickup wheel and point of measurement on a roll or moving web is measured as a speed variation, a vibration displacement pickup device is used sometimes along with the speed

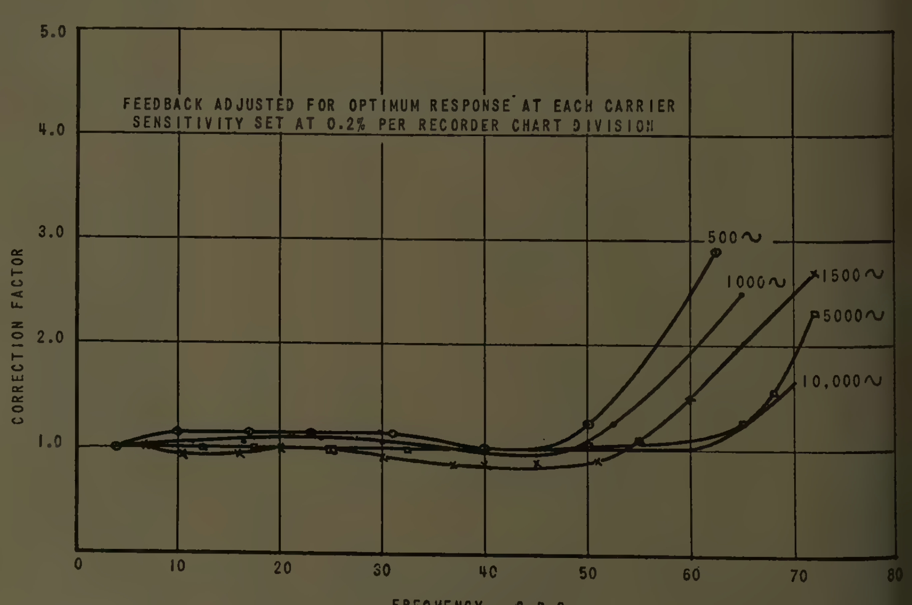
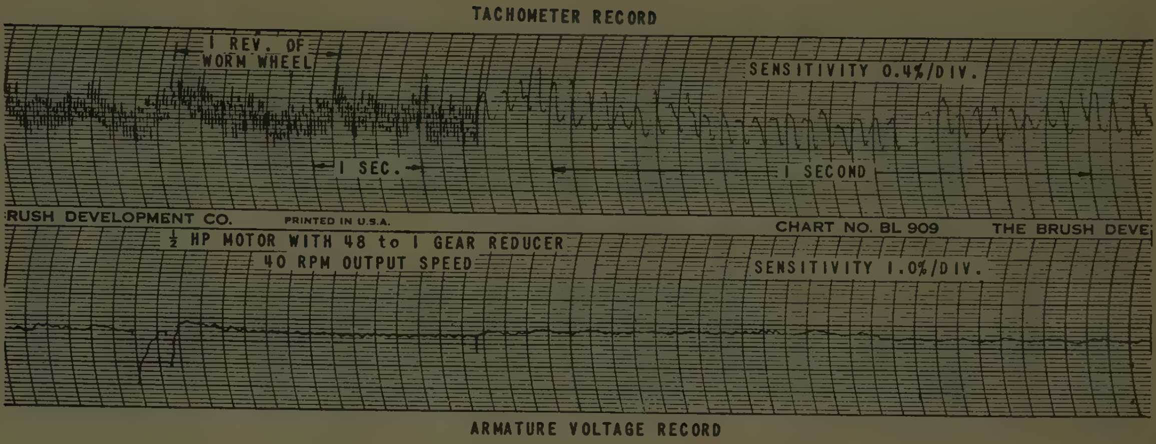


Figure 6. Over-all response of the tachometer for various carrier frequencies

Figure 7. Typical recorder chart. Upper curve represents speed variations of the output shaft, lower curve shows armature voltage



pickup unit to correlate results better. The vibration sensing device consists of either a piezo crystal or a linear differential transformer type device. The output of the sensing element is fed through a Brush a-c amplifier to the second channel of the recorder.

An oscilloscope is incorporated into the tachometer for checking the quality of the incoming signal from the speed sensing unit in respect to waveshape and amplitude variation. The oscilloscope also is used for checking other variables, signal tracing, and on-the-spot maintenance when the equipment is used as a portable unit away from the laboratory.

The speed sensing unit is applied at the rotating member or moving material under consideration. An indicator on the face of the frequency converter shows the carrier frequency generated by the speed sensing unit. This furnishes information for the proper setting of the calibrated feedback compensation potentiometer in the d-c amplifier and also indicates the machine speed at which the readings are being made.

With the gain control of the d-c amplifier set at a low value the output is applied to the recorder and the bucking voltage potentiometer is adjusted to reduce the recorder deflection to zero. The gain then is increased progressively while keeping the recorder on scale with the bucking voltage potentiometer until a conveniently measured modulation is obtained on the recorder. The gain control on the d-c amplifier is calibrated in terms of per cent speed variation per millimeter division on the recorder chart scale so that quantitative curves can be made.

A section of a typical chart taken from the recorder is shown in Figure 7. This record represents the speed variations on the output shaft of a d-c motor with an integral single-stage worm reducer having a ratio of 48 to 1. The motor is operating at a speed of 40 rpm on the output shaft. A speed variation of 3 per cent is shown clearly at a frequency of 32 cycles, which corresponds to the gear tooth frequency of the 48-tooth worm wheel.

The second channel on this chart represents the variation in direct voltage applied to the armature of the motor and is simultaneous with the tachometer reading.

The equipment has proved to be very satisfactory in the measurement of speed variations produced by various gear, belt, chain, and other drives. Resonance frequencies of various rotating systems have been established, and such things as torque pulsations, due to dead armature coils incorporated in the design of some d-c motors, have been measured.

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Philippines Get Mechanical Rectifier

A forward step in the industrialization of the Philippine Islands was taken recently when the first mechanical rectifier manufactured especially for them was demonstrated at the plant of the I-T-E Circuit Breaker Company. When it is put into operation outside Manila, the capital of the Philippines, it will make the Islands independent of outside chlorine services.

Power from the $700,000 plant will produce an estimated six tons of chlorine and caustic soda daily, which will be used for water chlorination, bleaching, and civil defense purposes. Designed to produce an uninterrupted source of d-c power to operate the new chlorine plant, the mechanical rectifier has a rating of 12,000 amperes and will deliver 65 volts d-c. The 3-phase voltage supplied to the primary side of the mechanical rectifier is 13,200 volts at 60 cycles.

Report on Plan for Recognition of Section Growth Presented

A Section growth plan was developed and adopted in District 2 for the years ending August 1, 1949, and August 1, 1950. The purpose of this plan was to encourage Sections by recognizing and rewarding outstanding effort. The plan seemed to have enough merit for Past-President LeClair to appoint a special committee to study a Section growth plan. This committee was to determine if this or a similar plan should be adopted on a national scale. Following is a report of this committee giving a formula for application of such a plan on a national basis and rules for application of this plan. This plan was approved by the Board of Directors on January 25, 1951.

Some interesting facts were discovered by the committee, which are discussed by C. G. Veinott, Chairman of the committee, in "Section Growth Award Plan" on page 757 of this issue.

Statistics for the Section Growth Recognition Plan for the year ending August 1, 1950, are given in Tables I, II, and III. It will be noted that in Table III figures are given for 88 sections, whereas only 74 Sections were eligible and accounted for in Tables I and II. These Sections were declared ineligible because they were less than four years old on July 1, 1950: Arkansas, Arrowhead, Canton, Miami, Niagara International, Northeast Michigan, Oak Ridge, Ottawa, Panhandle Plains, Richland, Rock River Valley, Sacramento, Shreveport, and Western Virginia. The average net membership of the 74 eligible Sections is 449.24.

DEVELOPMENT OF GROWTH FORMULA

Recognized purpose of this plan was to develop a method for stimulating Sections to put forth better efforts and better performance as Sections. The method was to develop a yardstick for measuring Section performance so as to add the element of competition to the normal incentive for the officers of each Section to obtain the best possible performance obtainable from that Section.

Requirements of the ideal yardstick were felt to be many. The yardstick should be fair to all Sections, large and small, old and young. It should be applicable to all Sections of the Institute. The formula should be easy to apply. It should contain no components involving personal judgment, so that no personal bias could creep into the results. The yardstick must be simple and preferably contain only items which are already obtainable from records available at National Headquarters. It should not be necessary to go to the Sections for additional records. The final basis for this yardstick was growth in membership and growth in attendance. Membership and attendance were considered the two most significant indications of a healthy Section. Members are an obvious essential since they provide the financial support of the Section, furnish the officer material for running the Section, and generally support the activities. However, a Section may have members but little or no attendance at meetings. A continuous high level of attendance at meetings would certainly be an indication that the Section was fulfilling a need of its members. A Section can have increasing membership and decreasing attendance. Thus, it would seem that a system based on number of members and attendance at meetings would provide a rather simple system for measuring the accomplishments of a Section.

Growth was selected as a basis for rating and comparing the Sections; that is, growth in membership and growth in attendance. This automatically means that a Section is compared on the basis of its own past performance. There appears to be no easy way to determine how large a Section should be in a particular area, nor is there any simple, direct correlation between attendance and number of members. Therefore, it seems impossible to set fair standards for either membership or attendance on an absolute basis. Measuring the membership at the end of each year and comparing it with the membership at the beginning of the year, also comparing the attendance of the year under consideration with previous years, means rating a Section on the basis of its own past performance. Possibly, this makes it slightly easier for a backward Section to win the growth award, but perhaps the backward Section needs more stimulus.

The growth formula finally selected by the committee is given in Appendix I. There the growth factor is defined as the per cent

Table I. Growth Factors of Large Sections

Name of Section	Net Membership as of 7/1/50	Per Cent Increase in Membership	Per Cent Increase in Attendance×1/3	Growth Factor
1. Connecticut	537	9.59	94.47	104.06
2. North Texas	500	29.87	6.23	36.10
3. Cleveland	813	14.83	16.09	30.92
4. Seattle	525	24.41	4.96	29.37
5. Washington	946	10.51	15.94	26.45
6. Milwaukee	785	14.10	12.02	26.12
7. Pittsburgh	1,202	14.48	8.40	22.88
8. Philadelphia	1,555	14.93	5.53	20.46
9. New York	5,245	7.39	11.55	18.94
10. St. Louis	609	16.89	0.82	17.71
11. Michigan	845	17.52	− 3.33	14.19
12. Chicago	1,846	14.09	− 2.53	11.56
13. Maryland	674	11.96	− 0.42	11.54
14. Portland, Oreg.	534	21.92	−11.04	10.88
15. Boston	924	10.92	− 2.74	8.18
16. Los Angeles	1,471	14.12	− 7.16	6.96
17. San Francisco	1,251	5.93	− 0.42	5.51
18. Schenectady	1,015	9.49	− 4.74	4.75
19. Toronto	628	12.75	− 8.93	3.82

Future AIEE Meetings

AIEE Conference on Aircraft Electrical Applications (*page 823*)
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 8–10, 1951

AIEE Conference on Fractional Horsepower and Motor Applications to Refrigeration Equipment and Pumps (*page 824*)
Dayton Biltmore Hotel, Dayton, Ohio
October 11–12, 1951

Fall General Meeting (*page 822*)
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—closed*)

AIEE Conference on Feedback Control Systems (*page 824*)
Haddon Hall Hotel, Atlantic City, N. J.
December 6–7, 1951

Joint AIEE-IRE Computer Conference
Benjamin Franklin Hotel, Philadelphia, Pa.
December 10–12, 1951

AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine
Hotel Statler, New York, N. Y.
January 7–8, 1952

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1952
(*Final date for submitting papers—October 23*)

South West District Meeting
Jefferson Hotel, St. Louis, Mo.
April 15–17, 1952
(*Final date for submitting papers—January 16*)

North Eastern District Meeting
Binghamton, N. Y.
April 30–May 2, 1952
(*Final date for submitting papers—January 31*)

Summer General Meeting
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—March 25*)

ıcrease in members, plus one-third of the ıcrease in attendance. Note that correcıon is made for territorial transfers by liminating from consideration for the parıcular year involved all members residing n territories transferred from one Section o another. This provision was adopted ecause otherwise it would be to the obvious lisadvantage of a Section to permit territory o be transferred away from it. Since most erritorial transfers are made for the good f the members concerned, it was desired y the committee not to introduce any lements that would tend to discourage a ection from co-operating with a transfer, lue to its not wanting to lose members, and hereby lose in the growth award. In some ases, if the number of members involved in he territorial transfer is not considered, it loes affect the relative positions of the ections directly concerned.

It will be noted that in the formula there s no correction made for attendance due o territorial transfer, except when a Subection becomes a Section. This was beause ordinary territorial transfers probably ave little adverse effect on the Section osing the territory since usually one of the najor reasons for the transfer was that the nembers were located too far away from heir parent Section and did not attend nyway. However, in the case of Sections aving Subsections which during the 4-year eriod under consideration become Secions, the attendance at meetings of such ubsections is excluded from the attendance ecord of the parent Section, for purposes of omputing growth.

It also will be noted that no provision is nade for individual members transferring rom one Section territory to another due to hange in residence. These are beyond the ontrol of the Sections anyway, and the umber of these transfers would be almost mpossible to determine and they would robably have little effect on the ratings.

Why was the growth in attendance rated nly one-third, whereas full rating was iven to growth in membership? Study f the records of the application of a growth lan in District 2 shows that the relative ating of the Sections was determined, for ll practical purposes, by the increase in ttendance rather than by the increase in nembers. It was felt that a Section is ntitled to more credit for improving its nembership than for improving its atendance. Moreover, the attendance records re inherently less accurate than the memberhip records, which are known exactly. ttendance records often are estimated, nd sometimes not as accurately as they hould be. Rating the attendance oneird automatically reduces the effect of is error on the growth factor. Moreover, will be noted that no distinction is made etween attendance of members, Student embers, and/or visitors. This is partly the interests of simplicity, and partly ecause this segregation is not always ossible from the records at Headquarters. addition, it is desirable to have visitors ecause these may be prospective members. any case, they are an indication that the ory of AIEE is being put across to those dividuals.

It will also be noted that the attendance of particular year is compared against a -year average for that Section. Experience District 2 showed that this was much

Table II. Growth Factors of Small Sections

	Name of Section	Net Membership as of 7/1/50	Per Cent Increase in Membership	Per Cent Increase in Attendance×1/3	Growth Factor
1.	Erie	167	28.46	56.37	84.83
2.	North Carolina	265	15.72	66.72	82.44
3.	Nebraska	140	29.63	37.76	67.39
4.	Memphis	171	37.90	24.61	62.51
5.	Arizona	195	48.85	6.59	55.44
6.	Fort Wayne	139	11.20	43.83	55.03
7.	South Carolina	147	20.49	31.60	52.09
8.	Central Indiana	313	34.91	14.10	49.01
9.	New Mexico and West Texas	193	30.41	16.00	46.41
10.	West Virginia	158	31.67	13.69	45.36
11.	South Texas	205	25.77	17.57	43.34
12.	Alabama	276	38.69	3.79	42.48
13.	Niagara Frontier	278	4.51	32.48	36.99
14.	Montana	111	23.33	12.13	35.46
15.	Mexico	213	−1.39	35.12	33.73
16.	Georgia	255	15.91	17.05	32.96
17.	New Orleans	309	25.61	3.58	29.19
18.	Louisville	138	20.00	4.37	24.37
19.	Lehigh Valley	373	14.77	7.64	22.41
20.	Providence	165	25.00	−3.45	21.55
21.	Rochester	234	9.35	11.16	20.51
22.	Dayton	382	12.02	7.69	19.71
23.	Virginia	198	17.86	1.74	19.60
24.	Oklahoma City	208	15.56	3.45	19.01
25.	Wichita	106	29.27	−10.60	18.67
26.	Minnesota	352	26.16	−8.24	17.92
27.	Lynn	298	12.03	5.81	17.84
28.	Cincinnati	266	12.71	4.55	17.26
29.	Sharon	201	12.92	4.10	17.02
30.	Tulsa	160	15.11	1.68	16.79
31.	Vancouver	207	18.29	−1.66	16.63
32.	Syracuse	250	5.49	10.92	16.41
33.	Denver	442	20.44	−5.27	15.17
34.	Beaumont	85	4.94	9.99	14.93
35.	Utah	137	26.85	−13.61	13.24
36.	Illinois Valley	145	18.85	−5.84	13.01
37.	Worcester	103	17.05	−4.58	12.47
38.	Spokane	154	20.31	−8.65	11.66
39.	Ithaca	213	18.33	−7.62	10.71
40.	South Bend	117	14.71	−4.67	10.04
41.	Kansas City	299	9.93	−2.40	7.53
42.	Akron	137	16.10	−13.89	2.21
43.	Florida	161	17.52	−15.98	1.54
44.	Toledo	129	11.21	−10.05	1.16
45.	Columbus	152	10.95	−9.80	1.15
46.	Iowa	202	8.02	−9.61	−1.59
47.	Madison	88	17.33	−20.04	−2.71
48.	Houston	290	7.01	−11.02	−4.01
49.	Mansfield	82	10.81	−16.00	−5.19
50.	San Diego	159	1.27	−6.87	−5.60
51.	East Tennessee	333	9.54	−16.77	−7.23
52.	Montreal	324	7.28	−20.61	−13.33
53.	Pittsfield	326	15.19	−29.56	−14.37
54.	Springfield, Mass.	95	7.95	−26.31	−18.36
55.	Urbana	93	−5.10	−31.90	−37.00

Table III. Growth Factors of the Districts*

	District and Location		Number of Sections**	Membership as of 7/1/50	Per Cent Increase in Membership	Per Cent Increase in Attendance×1/3	Growth Factor
1.	North Central	(6)	2	582	22.53	5.05	27.58
2.	South West	(7)	13	3,151	18.10	5.61	23.71
3.	Southern	(4)	14	2,671	13.80	7.55	21.35
4.	Middle Eastern	(2)	16	7,335	14.18	6.09	20.27
5.	North West	(9)	7	1,783	21.96	−2.96	19.00
6.	New York City	(3)	1	5,245	7.39	11.55	18.94
7.	Great Lakes	(5)	14	5,182	13.74	2.20	15.94
8.	Pacific	(8)	5	3,172	11.85	−2.10	9.75
9.	North Eastern	(1)	12	4,440	10.86	−4.32	6.54
10.	Canada	(10)	4	1,141	12.19	−9.36	5.00

Growth Factor for Institute

Total Membership in Sections as of 7/1/49	30,674	
Total Membership in Sections as of 7/1/50	34,702	
Per Cent Increase in Membership		=13.13 Per Cent
Total Attendance 1950	142,001	
Total 3-Year Average (47–50)	135,857	
Per Cent Increase×1/3		= 1.51 Per Cent
Growth Factor for Entire Institute		=14.64 Per Cent

* No correction for territorial changes has been made.

** The figures shown here are for 88 sections, although only 74 were eligible. The following sections were declared ineligible because they were less than four years old on July 1, 1950: Arkansas, Arrowhead, Canton, Miami, Niagara International, Northeast Michigan, Oak Ridge, Ottawa, Panhandle Plains, Richland, Rock River Valley, Sacramento, Shreveport, and Western Virginia. Average net membership of the 74 eligible Sections is 449.24.

fairer than comparing the current year's attendance with merely the attendance of the one single preceding year. By this arrangement, the attendance for a given year is compared against a more stable base, since it is a 3-year average, than if against only the preceding year. This has the effect of giving a higher attendance rating to a Section which is showing a consistently improving attendance than one which has a sudden spurt in attendance; likewise, it derates a Section more for a consistent falling off in attendance, but has little effect on a Section whose attendance is fluctuating from year to year. It does not penalize a Section so badly for having had a very good year the preceding year, nor does it unfairly allow a Section to make a kill one year when it has laid down on the job, or failed miserably, the preceding year.

Rules governing the Section growth award are given in Appendix II. It will be noted that the Sections of the Institute are divided into two groups, large and small Sections. The formula, as developed, does tend to favor somewhat the younger and smaller Sections, and particularly Sections in growing areas. Likewise, it is probably easier for a backward Section to win than for one which has been doing an excellent job for many years. However, if this growth plan should be the means of stimulating an otherwise backward Section to greater effort, it is certainly accomplishing a useful purpose. Perhaps a Section which has been backward for many years requires greater effort to stimulate it and, after all, it is performance and not effort that we wish to measure and record. It would not be possible to write the rules so that all Sections would have an equal chance of winning; the only way to do this would be to draw lots, and then the purpose of such an award would be meaningless.

CONCLUSIONS

After a careful consideration of the record of a Section growth plan, operated at a District level for two years, a plan for recognition of Section growth suitable for adoption on a national scale has, in the opinion of this committee, been developed and presented in this report. It is recommended that this plan be adopted on a national scale and given a fair trial. These rules can be changed or modified as experience shows such modification to be necessary.

APPENDIX I. GROWTH FACTOR FOR YEAR *X*

Growth Factor

$$100\left[\left(\frac{M_0-M_1}{M_1}\right)+\frac{1}{3}\left(\frac{A_0-A_a}{A_a}\right)\right]$$

where

M_0 = total members in the Section, as of August 1, year X, less all members residing in territory which has been transferred to the Section during the year ending August 1, X.

M_1 = total members in the Section as of August 1, $X-1$, less all members residing in territory which has been transferred from the Section during the year ending August 1, X.

A_0 = total attendance at all meetings directly sponsored by the Section for the year ending May 1, X.

A_a = average total attendance at all meetings directly sponsored by the Section for the three consecutive years immediately preceding year X.

Figures for A_0 and A_a include attendance at meetings of all Subsections which are still a part of the Section, August 1, X. If a Subsection becomes a Section at any time before August 1, X, attendance at the meetings of that Subsection is excluded from both A_a and A_0.

APPENDIX II. RULES GOVERNING SECTION GROWTH AWARD

1. All Sections shall be automatically considered.
2. To be eligible for a growth award, a Section must have been in operation for four full consecutive years, and have reports of these four years filed at National Headquarters.
3. Any Section may be disqualified by the judging committee if it finds anything in the Section's particular record so abnormal as to give it an unfair advantage over the other Sections.
4. Growth factors for all the eligible Sections will be computed by the committee. The size of the average eligible Section at the end of the year under consideration will be computed and the Sections divided into two groups:
   a. Large Sections—Sections which have a membership greater than the average eligible Section.
   b. Small Sections—Sections which have a membership equal to, or less than, the average eligible Section.
5. First and second prizes will be awarded to the two Sections in each group having the highest and second highest growth factors in each group. Each first prize will be a gavel, suitably inscribed. Each second prize will be a certificate, suitably engraved.
6. These prizes are to be presented at the Summer General Meeting of the Institute.

Respectfully submitted,

Special Committee to Study Section Growth Plan

C. G. Veinott, *Chairman*
D. I. Anzini
Charles Clos

New Plants and Equipment to Be Inspected at Fall General Meeting

Final plans have been made for the technical sessions, entertainment program, and inspection trips schedule for the 1951 Fall General Meeting to be held in Cleveland, Ohio, October 22 through 26. Headquarters will be at the Hotel Cleveland.

TECHNICAL PROGRAM

On Monday, October 22, sessions are being sponsored by the committees on System Engineering, Insulated Conductors, Rotating Machinery, and Industrial Control.

Tuesday morning the general session will be held at which a prominent speaker will address the members. In the afternoon the technical program will be resumed with sessions on the Production and Application of Light, Management, Rotating Machinery, Insulated Conductors, and a conference on Transmission and Distribution.

Wednesday, sessions on Rotating Machinery and Transmission and Distribution will continue in the morning with sessions on Wire Communications, Power Generation, and Safety added. In the afternoon the Safety and Transmission and Distribution sessions will continue with those on Television Systems and Relays.

Thursday morning, sessions on Transformers, Basic Sciences, Radio Communications, and Instruments and Measurements will be held. In the afternoon the program continues with sessions on Feedback Control Systems, Instruments and Measurements, and Communication Switching.

For Friday, sessions are scheduled in the morning on Cathodic Protection, Electronics, Magnetic Amplifiers, and Mining. In the afternoon the technical program will conclude with sessions on Industrial Power Systems, Electronics, and Steel.

INSPECTION TRIPS

The Trips Committee for the Fall General Meeting has completed final arrangements for a number of inspections of Cleveland and surrounding industry. New plants and equipment embodying the latest developments in up-to-date manufacturing, design, and operating practices will be seen.

The Lincoln Electric Company's plant in nearby Euclid is one of these. It is thought to be one of the most, if not the most, modern and uniquely designed plant in the nation and the world. Each segment of the production function in the manufacture of welding supplies and equipment was analyzed and the plant design made to accommodate the most efficient performance of these functions.

Another trip will be the inspection of the Republic Steel Company's Cleveland plant which carries on all of the basic steel making operations. In addition to the spectacular operations of a steel plant, members will have an opportunity to observe electric power and control equipment in operation.

The trip to Nela Park of the General Electric Company will emphasize the engineering and development aspects of the electric lamp industry. In addition, many examples of the application of lighting will be on display for appraisal and demonstration.

The Goodyear Rubber Company plant at Akron, Ohio, will show the operations in building automotive and industrial rubber tires. Many of these operations are electrically powered and controlled to achieve the maximum in quality and output.

Members interested in industrial control may visit the plant of the Clark Controller Company. Here they can observe the manufacture of heavy-duty standard and specially engineered industrial electric control equipment. Clark has pioneered in a number of electric control fields, among which are the steel and the automotive industries.

Another trip to an electrical manufactur-

ng plant will be to the Reliance Electric nd Engineering Company, manufacturers f electric rotating machinery. Construc-on of integral horsepower a-c and d-c nachines through approximately 500 horse-ower may be observed.

Another of the entirely new plants to be isited is the Cleveland Engine Plant of the 'ord Motor Company, where operation of a nodern industrial electric distribution system an be seen. Portions of the plant are till under construction, but the completed ortions of the plant and their manufactur-ng operations will be open for inspection.

Several other trips are planned and will e announced later pending defense security egulations in effect at the time of the neeting.

Advance reservations for inspection trips hould be made by means of the advance egistration card; however, remaining avail-ble tickets will be obtainable at the meeting t the Inspection Trips Desk. A nominal harge will be made to cover the cost of ransportation to and from inspection trip ites.

ENTERTAINMENT

The entertainment program will begin Sunday afternoon, October 21, from 3 to 5 P.M. with a "get acquainted" and social our at the Hotel Cleveland.

Tuesday evening, October 23, has been eserved for the men's smoker, including inner. A lively and entertaining show has een booked for presentation following inner. Tickets for this affair must be rranged for in advance.

On October 24 the traditional dinner ance will be held in the ballroom of the Hotel Cleveland for members and their lady uests. Dress for the occasion will be ptional. Tickets will be available at the Registration Desk.

The Cleveland Playhouse 77th Street Theater has been booked for Thursday vening. This is a unique show house vith a half-arena stage, sometimes called the apron" or "Shakespearian" stage. The udience sits in a semicircle surrounding the layers. There is no curtain and scene hanges are accomplished under blackout. Anne of the Thousand Days," by Maxwell nderson, will be presented. Following he presentation, refreshments will be served ackstage where AIEE members and guests nay meet the cast.

LADIES' PROGRAM

Monday, October 22, has been reserved or registration and antique tours, or a visit o General Electric's Nela Park. Advance rrangements should be made with the ostesses at the Registration Desk for the ntique tour or the Nela Park visit. Coffee vill be served on Monday morning from :00 to 11:00 in the Ladies' Headquarters.

A "get acquainted" tea will be held Tuesday afternoon from 3:00 to 5:00 P.M. t the University Club. At 8:00 P.M. in he Hotel Cleveland the ladies will witness he showing of a presentation entitled, Have You Seen the Garden of Eatin'?"— terally, a cook's tour.

Wednesday's program includes a bus rip to Cleveland's Museum of Art, Cultural Gardens, and Historical Society Museum. Refreshments will be served before returning o the hotel. Busses for the trip will leave Hotel Cleveland at 1:00 P.M. A charge of $1.00 per person will be made for transportation.

The Cleveland Terminal Tower, looking north to the Stadium and Public Auditorium, with the Hotel Cleveland to the left of the Tower and Lake Erie in the background

A luncheon and style show at the Canterbury Golf Club is scheduled for Thursday. Busses will leave Hotel Cleveland at 12:15 P.M.

A charge of $1.00 per person will be made for transportation.

The ladies are reminded of the dinner dance on Wednesday evening and the theater party on Thursday evening listed in the entertainment program.

HOTEL INFORMATION

Rooms will be available at the headquarters hotel, Hotel Cleveland, at the following rates:

Single Bedroom—$4.50, 5.00, 5.50, 6.00, 7.00, and 8.00.
Double Bedroom—$7.00, 7.50, 8.00, 9.00, and 10.00.
Twin Bedroom—$9.00, 10.00, 11.00, 12.00, and 14.00.
Parlor, 1 Bedroom (occupancy by one or two persons)—$18.00 and up.
Parlor, 2 Bedrooms (occupancy by three or four persons)—$30.00 and up.

All of these accommodations are with bath.

Cards for making room reservations will be mailed to the Institute membership later.

In addition, rooms may be reserved at the Hollenden, Statler, or Carter Hotels by writing directly for reservations.

AIEE Conference on Aircraft Electrical Applications to Be Held in Los Angeles

Greater Los Angeles, the hub of the nation's largest aircraft industry, will play host to the AIEE Technical Conference on Aircraft Electrical Applications on October 8, 9, and 10; headquarters will be at the Hollywood Roosevelt Hotel.

This conference, sponsored by the AIEE Committee on Air Transportation, is part of a co-ordinated program that allows visiting delegates to combine three conferences with business obligations, thereby encouraging the most profitable utilization of their time. There is a full week of aircraft technical conferences in Los Angeles: the annual Society of Automotive Engineers (SAE) meeting on October 3, 4, and 5 at the Biltmore Hotel; the annual Aircraft Electrical Society (AES) display October 9 and 10 at the Los Angeles Institute of Aeronautical Sciences Building; and the AIEE conference.

Within a half-hour drive of the Hollywood Roosevelt Hotel are these major aircraft companies: Douglas Aircraft Company, Inc.; Lockheed Aircraft Corporation; Hughes Aircraft Company; North American Aviation, Inc.; and Northrop Aircraft, Inc.

WHY THE HOLLYWOOD ROOSEVELT?

The beautiful Hollywood Roosevelt Hotel, in the heart of Hollywood, offers not only the best in modern hotel living but also has the unique advantage of being equidistant from the area's aircraft companies. Conference visitors, thus aided by location, can conduct their business obligations with a minimum of travel delay. Not only will delegates enjoy free access to the hotel's beautiful swimming pool on the warm October days, but they will find themselves in the heart of Hollywood's fabulous entertainment world. A block of rooms has been reserved by the Roosevelt for AIEE visitors, but reservations must be received by the hotel before September 28.

Other convenient hotels in the same general area and with the same moderate prices are the Hollywood Knickerbocker, Beverly Hills Hotel, Ambassador Hotel, and the Beverly Wilshire Hotel.

Members should register in advance by promptly filling in and mailing the registration and hotel card to C. R. Moore, 1009 Arbor Vita, Inglewood 1, Calif.

TECHNICAL SESSIONS

An active program has been prepared under the chairmanship of H. F. Rempt. The tentative schedule includes technical sessions the afternoon of October 8 and morning and afternoon sessions on October 9 and 10. The morning of the opening day will be devoted to registration. Luncheons are planned from 12 to 2 October 9 and 10 at the headquarters hotel. The evenings of October 9 and 10 from 7 to 10 will be given over to the AES Aircraft Manufacturing Display.

TECHNICAL PAPERS

"Aircraft Electrical Installation and Environmental Problems" is the general theme for papers to be presented at this meeting. The Program Committee has offered to review all papers prior to the conference. This will enable authors to focus their presentation on the most effective points. Where possible, the Program Committee will introduce late papers into the program. Three copies of each paper should be submitted, and they should be sent to Mr. Bill Berry, Conference Secretary, Hughes Aircraft Company, Culver City, Calif.

AES ANNUAL DISPLAY

Those attending the conference are cordially invited to attend the Aircraft Electrical Societies annual display and dinner. Admission will be by invitation only, but invitations to attend one evening will be available at the AIEE registration desk. Exhibits from 35 companies will be included in the displays.

LADIES' ENTERTAINMENT

The entertainment committee has arranged a varied program of activities and entertainment for the ladies during the conference. Los Angeles and Hollywood offer stage shows, operas, symphonies, horse racing at Hollywood Park, swimming at the Roosevelt Pool, guided tours of points of interest, numerous famous night clubs, golf clubs, and sports of every variety.

Fractional Horsepower Conference Scheduled for Dayton, Ohio

The Fractional Horsepower and Single-Phase Subcommittee of the Rotating Machinery Committee, in conjunction with the Domestic Appliances Subcommittee and the Dayton Section of AIEE, has scheduled a technical conference on the application of fractional horsepower motors to refrigeration equipment and pumps to be held at the Dayton Biltmore Hotel, Dayton, Ohio, on October 11 and 12.

Papers on refrigeration applications will be presented October 11 and a trip through the Frigidaire plant is planned in the evening. Pump application papers will be presented October 12. Three papers are scheduled on the application of motors to refrigeration and air-conditioning equipment, and five on motor applications to various types of pumps. In addition, papers on starting relays for refrigeration motors, automatic defrost controls, low-temperature insulation characteristics, and Fiberglas in the wire and cable industry complete the program.

For information regarding registration, hotel accommodations, and so forth, contact Mr. D. C. Breeding, Frigidaire Division, General Motors Corporation, Dayton, Ohio.

Conference on Feedback Control Systems Planned for Dec. 6–7

The Feedback Control Systems Committee is making plans for a 2-day conference December 6–7 to be held at Haddon Hall Hotel, Atlantic City, N. J. In its first technical conference this committee is hoping to recapitulate the significant developments in this subject, particularly electric servomechanisms dealing with biological aspects, with new component developments, and with analytical design procedures. The AIEE committee was formerly known as the Joint Subcommittee on Servomechanisms.

The technical program has been arranged and will be described in more detail in a subsequent issue of *Electrical Engineering*.

Resolution Concerning Inactive Membership Status Adopted

A resolution authorizing inactive membership status because of military service was adopted by the AIEE Board of Directors on June 28, 1951. The resolution follows: RESOLVED to adopt and publish in *Electrical Engineering* the following policy: Every member who enters active service in the armed forces shall have the option of continuing to pay dues as an active member, and having all publications sent to his permanent address, or of being an inactive member, without publication privileges, and without payment of dues beginning with that quarter of the Institute's fiscal year in which he requests such change in membership classification. Such inactive members will be expected to resume active membership and the payment of dues within three months after their severance from military service, with the same status in all respects as existed at the time of entering the service.

New AIEE Subsection in Racine-Kenosha Area Formed

The attendant disadvantages of traveling long distances to Milwaukee caused the formation of a local subsection. The Racine–Kenosha area has a large number of electrical equipment manufacturers. Many electrical engineers in this area have never been AIEE members due to the difficulty in attending meetings. The formation of the new subsection has assisted greatly in signing up new members. Average attendance to all the meetings has been good—at least 40, with a high of 70.

The first organization meeting was held in February, and the subsection was recognized by the Milwaukee (Wis.) section in May, and approved at the Summer General Meeting in Toronto, Canada.

Officers are: C. B. Lee, *Chairman;* J. B. Winther, *Secretary-Treasurer;* and L. Upton, R. L. Jaeschke, and H. Servis, *Directors.*

Lamme Medal Nominations Must Be Submitted by December 1

Members of the Institute again are reminded that they have an opportunity to submit nominations for the 1951 AIEE Lamme Medal. All nominations must be received not later than December 1, 1951. Details regarding qualifications were published in the June 1951 issue of *Electrical Engineering*, page 551.

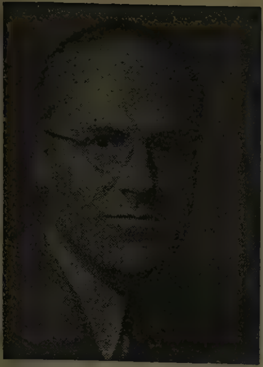
COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Note. Because of the changeover in committee personnel, no items on committee activities are included in this issue.

AIEE PERSONALITIES . . . . .

D. C. Prince (A '16, F '26), Vice-President, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y., has retired after 32 years of service to the company. Mr. Prince is a Past-President of the AIEE (1941–42), and Lamme Medalist (1945). He joined General Electric in 1913 and except for two years during which he served as a First Lieutenant in the United States Army in World War I he has served the company continuously. He has held the positions of chief engineer of the Switchgear Department, commercial engineer, Vice-President in Charge of Application Engineering for the Apparatus Department, and Head of the General Engineering Laboratory in 1945. Responsible for many developments in the electrical engineering field, Mr. Prince holds 98 patents. He has been an active member of the Institute serving as a Director (1938–41), and on the following AIEE Committees: Protective Devices; Lamme Medal; Board of Examiners; Finance; Edison Medal;



D. C. Prince

I. M. Stein

W. R. Way

D. R. Shoults

Transfers; Air Transportation; John Fritz Medal Board of Award; Planning and Coordination; Technical Program; and the Hoover Medal Board of Award. Mr. Prince is a member of The American Society of Mechanical Engineers, the Institute of Radio Engineers, the Institute of Aeronautical Sciences, the Society of Automotive Engineers, the American Association for the Advancement of Science, and The Institution of Electrical Engineers.

I. M. Stein (A '18, F '39), Vice-President and Director of Research, Leeds and Northrup Company, Philadelphia, Pa., has been elected Executive Vice-President of the company. Mr. Stein was born on March 30, 1894, in Long Branch, N. J., and was educated at the Edison Technical School and Columbia University. From 1911 to 1917 Mr. Stein was associated with the New York Edison Laboratories, serving for four years as chief of the company's standards laboratory. During 1918 he served in the Eastern Department of United States Signal Corps. A year later Mr. Stein began his association with Leeds and Northrup. He became Research Director in 1928, and Vice-President in Charge of Research in 1944. During World War II he served as a member of the National Defense Research Committee. For his work on this committee he received a President's Certificate of Merit. Mr. Stein is an active member of the AIEE having served as a Vice-President (1937–39) and on the following Institute committees: Membership (1926–27, 1931–33); Sections (1929–41, Chairman 1933–36); Planning and Coordination (1933–44); Award of Institute Prizes (1936–40); Technical Program (1936–41); Constitution and By-Laws (1938–46, Chairman 1941–44); Institute Policy (1938–40); Lamme Medal (1941–44); and Edison Medal (1946–51). Mr. Stein is a member of The American Society of Mechanical Engineers, the American Physical Society, the American Chemical Society, the American Electrochemical Society, and the Franklin Institute.

W. R. Way (M '42), general superintendent, Generation and Transmission Department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been appointed Vice-President of the company. Mr. Way was graduated from McGill University in 1918 with a bachelor of science degree in electrical engineering. He became associated with the Shawinigan Water and Power Company after his graduation and after six years in the Montreal office as assistant engineer in the protection, metering, and hydraulic test divisions, he was transferred to Shawinigan Falls in 1924 as chief system operator. He returned to Montreal in 1930 as assistant superintendent of operation, then became successively superintendent, assistant general superintendent, and in 1944, general superintendent. Mr. Way is currently serving the AIEE as Vice-President of the Canadian District (number 10). He has served the Institute on the Power Generation Committee (1945–46), and the Membership Committee (1947–49). He is also a member of the Corporation of Professional Engineers of the Province of Quebec, member of the executive committee of the Canadian Electrical Association, and of the Engineering Institute of Canada.

D. R. Shoults (A '35, F '48), director of engineering, Aro, Inc., St. Louis, Mo., has been appointed director of the General Electric Company's Aircraft Nuclear Propulsion project for the Air Force and Atomic Energy Commission. Mr. Shoults was graduated from the University of Idaho in 1925 and became associated with the General Electric Company that same year. He worked in industrial and application engineering, and in 1942 was made engineer in the aviation division. In 1945 Mr. Shoults joined Bell Aircraft, serving as Vice-President of Engineering for two years. In 1947 he became Vice-President of Engineering for the Glenn L. Martin Company and three years later he joined Aro, Inc. Mr. Shoults has 20 patents to his credit and is the author of several technical articles. He has actively served the Institute on the following committees: Air Transportation (1942–45, Chairman 1944–45); Technical Program (1944–45); Standards (1944–45); and the Award of Institute Prizes (1944–45). He is a member of the Society of Automotive Engineers and The American Society of Mechanical Engineers.

H. L. Andrews (A '16, M '26), Vice-President in Charge of Appliance and Merchandise Department, General Electric Company, Bridgeport, Conn., has retired from the company after 41 years of service. He was born on October 25, 1889, in Boonville, Mo., and was graduated from the University of Missouri in 1910 with a bachelor of science degree in electrical engineering. Following his graduation he began his career with General Electric and after holding various positions in motor and railway engineering he was appointed to the position of engineer in charge of the company's Transportation Engineering Department in 1929. In 1934 Mr. Andrews was elected a Vice-President in Charge of Steam Railroad Electrification and one year later became responsible to the president of the company for all transportation activities of the company. In this capacity he was identified with the electrification of the Pennsylvania Railroad and the New York, New Haven and Hartford Railroad. In 1939 Mr. Andrews was placed in charge of the Appliance and Merchandise Department. He was in charge of the company's activities in all types of electric appliances. In the early part of 1951 Mr. Andrews was elected an Executive Vice-President. He served the Institute on the Transportation Committee (1932–34).

Robert Paxton (A '26, F '48), Vice-President in Charge of Manufacturing Policy, General Electric Company, Pittsfield, Mass., has been elected an Executive Vice-President and will assume responsibility for the company's Industrial Products and Lamp Group. He was born in Edinburgh, Scotland, in 1902, and was graduated with the degree of electrical engineer from Rensselaer Polytechnic Institute in 1923. He joined the General Electric Test Course immediately after graduation. He was transferred to the company's Philadelphia Works in 1927, where he rose through several positions to that of manager in 1941. In 1945 he became manager of the Pittsfield, Mass., Apparatus Works, and in 1948 was named manager of the Transformer and Allied Products divisions. In 1950 Mr. Paxton was appointed manager of manufacturing policy and later was elected Vice-President in Charge of Manufacturing Policy. He is a member of Sigma Xi.

R. C. Freeman (M '44), engineering manager, Welding Divisions, General Electric Company, Fitchburg, Mass., has been appointed to the position of manager. A graduate of the University of Minnesota, Mr. Freeman joined General Electric in 1929 as a student engineer on the company's Test Course. Shortly thereafter, he was transferred to the company's plant in Lynn, Mass., where he was assigned to the motor design engineering division. In 1937 Mr. Freeman became section engineer and in

1946 he assumed the post of division engineer at Fitchburg. He was named manager of engineering two years later. He is a member of the American Welding Society, and has served the AIEE on the Electric Welding Committee (1947–51). **A. U. Welch, Jr.** (A '36, M '47), division engineer, Welding Division, General Electric Company, Fitchburg, Mass., will succeed Mr. Freeman as manager of engineering. He has been with the company since 1929. Until 1947, he was located in the power transformer section, Pittsfield, Mass. He was appointed arc-welding section engineer in 1945 and division engineer in 1947. In 1949, Mr. Welch was transferred to Fitchburg as division engineer of the welding development division. He has received 13 patents on welding equipment.

C. J. Breitwieser (A '33, M '44), chief, electronics and engineering laboratories, Consolidated Vultee Aircraft Corporation, San Diego, Calif., has been named executive assistant to the Vice-President in Charge of Engineering at P. R. Mallory and Company, Inc., Indianapolis, Ind. A graduate of the University of North Dakota, Doctor Breitwieser holds a master of science degree from the California Institute of Technology and an honorary doctor of science degree from the University of North Dakota. He is the author of several technical articles and is a member of the Institute of Radio Engineers, the American Association for the Advancement of Science, the American Institute of Physics and Sigma Xi. He has served on the AIEE Air Transportation Committee (1944–48), and the Electronics Committee (1948–51).

Gano Dunn (A '91, F '12, HM '45, Member for Life), President, The J. G. White Engineering Corporation, New York, N. Y., has been named Chairman of the Trustees of The Cooper Union. Formerly Doctor Dunn was President of the corporation; this change is one of title, not of function or responsibility. He continues as the chief executive officer of the corporation. Doctor Dunn is a Past-President of the AIEE (1911–12), Edison Medalist (1937), and Hoover Medalist (1939).

J. H. Goss (A '35, M '43), manager of engineering, control engineering division, General Electric Company, Schenectady, N. Y., has been appointed staff assistant to the general manager of the company's small apparatus divisions. Mr. Goss joined the General Electric Company in 1930 after graduating from the University of Arkansas with a bachelor of science degree in mechanical engineering. He was named engineer in charge of the West Lynn (Mass.) Works Laboratory in 1936 and ten years later became assistant to the works engineer. In 1947 Mr. Goss was transferred to the control engineering division where he was made assistant manager of engineering and later manager of engineering.

J. H. Behm (A '50), division engineer, **R. D. Jones** (A '30, M '47), section engineer, and **I. E. Ross, Jr.** (M '44), assistant division engineer, all of the Fractional Horsepower Motor Engineering Divisions, General Electric Company, Fort Wayne, Ind., have been appointed respectively to the following positions: assistant to the manager of engineering on special assignments; division engineer of the development engineering division; and division engineer of the d-c and specialty motor engineering division.

E. O. Shreve (A '06, Member for Life), retired, New York, N. Y., was awarded the 1951 Iowa State College Alumni Recognition Medal in recognition of long and outstanding service to Iowa State College, its alumni activities, and its ideals. Mr. Shreve was retired recently from the General Electric Company where he held the position of Vice-President. He was the 1938 winner of the Marston Medal in recognition of his achievement in the field of engineering. He is also a member of The American Society of Mechanical Engineers.

D. D. Mallory (A '31, M '45), Director of Engineering, Toledo Scale Company, Toledo, Ohio, has been elected Vice-President in Charge of Engineering. Before joining the Toledo Scale Company in 1943, Mr. Mallory was associated with the Radiation Laboratory at the Massachusetts Institute of Technology, and prior to that he was Head of the Department of Engineering at Valparaiso University, Valparaiso, Chile. Mr. Mallory is also a member of the National Society of Professional Engineers and the American Society for Engineering Education.

G. H. Campbell (A '31, M '43), sales engineer, General Electric Company, Newark, N. J., has been appointed manager of the company's Newark office. Mr. Campbell joined the General Electric Company in 1924 following his graduation from the University of Pittsburgh. He was assigned to the central station division of the New York office in 1926 as a sales engineer. In 1947 he was transferred to the Newark office and was placed in charge of the central station division.

J. G. Holm (A '24, M '29), electrical engineer, New York, N. Y., has accepted the position of chief electrical engineer of Harold T. Smith, Inc., Ecuador. Prior to his latest appointment he had been associated with the Westinghouse Electric Corporation, Stone and Webster Engineering Corporation, the Port of Boston, and Gibbs and Hill, Inc. In his new position, Mr. Holm will be responsible for studies, design, and construction of power plants, transmission, and distribution systems.

L. M. Stauffer (M '41), manager, Salt Lake Office, General Electric Company, Salt Lake City, Utah, has been appointed manager of the Rocky Mountain Apparatus District of General Electric. Mr. Stauffer was graduated from Stanford University in 1922 with a bachelor of arts degree, and a year later he received a degree in electrical engineering. In 1925 he joined General Electric as an engineer.

W. W. Lewis (A '09, F '38, Member for Life), professor of electrical engineering, Union College, Schenectady, N. Y., has been appointed visiting professor of the Electrotechnical Institute, University of Sao Paulo, Brazil, for a 3-month term. He will lecture on high-voltage phenomena and direct laboratory work in this field.

OBITUARY • • • •

Louis Edward Underwood (A '03, M '13, Member for Life), retired, Pittsfield, Mass., died on June 30, 1951. He was born in Tolland, Conn., on June 22, 1876, and was graduated from the Sheffield Scientific School of Yale University in 1896. In 1897 he entered the Test Course of the General Electric Company and served continuously with the company until his retirement in 1945. He was appointed engineer of the D-C Motor Department in 1900; in 1927 he was appointed managing engineer of the Motor Department; and in 1932 Mr. Underwood became manager of the Pittsfield Works of the General Electric Company, which position he retained until his retirement. He served on the AIEE Committee on Industrial and Domestic Power (1918–20).

Francis Howard Doremus (A '24, M '32), manager, apparatus sales, General Electric Company, Denver, Colo., died on June 2, 1951. He was born on April 12, 1901, in Neligh, Nebr., and was graduated from the University of Nebraska in 1922 with a bachelor of science degree in electrical engineering. After his graduation Mr. Doremus joined the General Electric Company as a student engineer on the Test Course which he completed in 1924. He then was assigned to the industrial engineering and commercial division in Schenectady, N. Y. In 1925 he was transferred to the Denver office as industrial sales engineer, becoming manager of the Rocky Mountain District Industrial Division in 1938. In 1945, Mr. Doremus became district manager of apparatus sales.

A. Warren Thompson (A'07, M'27), retired, Stanwood, Wash., died on June 21, 1951. He was born on October 2, 1882, in Pamano Island, Seattle, Wash. In 1907, he received a bachelor of science degree in electrical engineering from the University of Washington. After graduation he became associated with the Seattle-Tacoma Power Company (now the Puget Sound Power and Light Company) as a substation operator. Following several intervening positions, Mr. Thompson joined the Carolina Power and Light Company, Raleigh, N. C., in 1919, and served as chief engineer of the company until his retirement in 1938. He was also an associate member of the Illuminating Engineering Society.

John R. Leinbach (A'24, M'33), chief electrical engineer, Lehigh Portland Cement Company, Allentown, Pa., died on June 19, 1951. He was born on May 27, 1889, in Rossville, Ga., and was graduated from the Georgia School of Technology in 1914, with

a bachelor of science degree in electrical engineering. After serving with various companies, among them the Toledo Blast Furnace Company, Toledo, Ohio, the Sunnyside Mining and Milling Company, Eureka, Colo., and the Elkhorn Coal Corporation, Fleming, Ky., Mr. Leinbach became associated with the Lehigh Portland Cement Company in 1926.

William Gibson Stanley (A'46), carrier service engineer, Federal Telephone and Radio Corporation, Clifton, N. J., died on May 18, 1951. He was born on October 9, 1900, in Holton, Kans., and attended the University of California and Columbia University. From 1929 to 1943 Mr. Stanley was carrier telegraph development engineer for the Postal Telegraph and Cable Company, New York, N. Y. In 1943 he was placed in charge of telegraph communication for the Federal Telephone and Radio Company.

MEMBERSHIP . . .

Recommended for Transfer

The board of examiners at its meeting of July 19, 1951, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Austin, B. O., mgr., aviation engg. section, Westinghouse Electric Corp., Lima, Ohio
Birchard, W. E., asst. div. engr., General Electric Co., Pittsfield, Mass.
Brady, B., engg. superintendent, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Brennecke, C. G., professor & head, elec. engg. dept., North Carolina State College, Raleigh, N. C.
Ingram, S. B., electronic apparatus dev. engr., Bell Telephone Laboratories, Murray Hill, N. J.
Inman, D. E., northwestern engg. & service mgr., Westinghouse Electric Corp., Chicago, Ill.
Knipmeyer, C. C., head, elec. engg. dept., Rose Polytechnic Institute, Terre Haute, Ind.
LeVesconte, L. B., elec. engr., Sargent & Lundy, Chicago, Ill.
McMorris, W. A., section engr., General Electric Co., Pittsfield, Mass.
Olsen, M. L., outside plant engr., Southwestern Bell Telephone Co., Oklahoma City, Okla.
Weaver, A. B., district engr., Central Power & Light Co., San Benito, Tex.
Weed, L. J., head, distribution div., Boston Edison Co., Boston, Mass.
West, H. R., dev. engr., General Electric Co., Pittsfield, Mass.

13 to grade of Fellow

To Grade of Member

Ackermann, O., senior design engr., Westinghouse Electric Corp., Pittsburgh, Pa.
Anderson, H. A., chief incandescent engr., Duro-Test Corp., North Bergen, N. J.
Anthony, C. W., substations supervisor, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Balzer, H. W., supervisor, circuit adaptation dept., Automatic Electric Co., Chicago, Ill.
Black, J. H., mgr., Westinghouse Electric Corp., Wilkes-Barre, Pa.
Booth, A. E., elec. engr., Arthur E. Booth Co., Los Angeles, Calif.
Bourbonnais, T. L., II, system relayman, Idaho Power Co., Boise, Idaho
Bozzella, S. J., elec. planning engr., Long Island Lighting Co., Garden City, N. Y.
Brandt, R., engr., New England Power Co., Boston, Mass.
Bryan, W. S., physicist, W. S. Bryan Co., Seattle, Wash.
Bucholz, C. S., asst. area engr., hanford works, General Electric Co., Richland, Wash.
Buckley, E. F., elec. engg. instructor, Massachusetts Institute of Technology, Cambridge, Mass.
Bunce, H. B., marine & aviation engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Burns, L. H., product engr., The National Telephone Supply Co., Cleveland, Ohio
Campbell, H. E., application engr., General Electric Co., Schenectady, N. Y.
Cartwright, P. A., asst. professor, elec. engg. dept., University of Minnesota, Minneapolis, Minn.
Clark, M. R., elec. engr., research labs., Bendix Aviation Corp., Detroit, Mich.
Corfield, C. C., hydro plant supt., Puget Sound Power & Light Co., Snoqualmie, Wash.
Crouse, C. H., Jr., elec. engr., Robbins & Myers, Inc., Springfield, Ohio
Dickinson, T. M., project engr., General Electric Co., Schenectady, N. Y.
Dugan, D. J., elec. engr., State Public School Building Authority, Harrisburg, Pa.
Edwards, W. T., Jr., engr., Southern Bell Telephone & Telegraph Co., Atlanta, Ga.
Elliott, R. G., plant extension engr., The Pacific Telephone & Telegraph Co., Los Angeles, Calif.
Emich, H. C., elec. engr., Riggs Distler & Co., Philadelphia, Pa.
Evans, J. T., product application engr., Bull Dog Electric Products Co., Detroit, Mich.
Farrell, C. C., elec. engr., Philadelphia Electric Co., Philadelphia, Pa.
Farrington, W. H., senior engr., Texas Electric Service Co., Fort Worth, Tex.
Fisher, D., operating results supervisor, American Telephone & Telegraph Co., New York, N. Y.
Flynt, E. R., research engr., assistant professor, state engg. experiment station, Georgia Institute of Technology, Atlanta, Ga.
Gladis, J., elec. engr., Ebasco Services, Inc., New York, N. Y.
Glassman, A., elec. engr., Electro-Switch & Controls, Inc., Culver City, Calif.
Hart, L. K., sales engr., Square D Company Canada, Ltd., Montreal, Quebec, Canada
Hinshaw, W. W., elec. engr., University of Illinois, Urbana, Ill.
Hoffman, C. H., engr., electric distribution dept., Public Service Electric & Gas Co., Newark, N. J.
Horkay, T. E., div. engr., Cia Nacional de Electricidad, S.A., Torreon, Mexico
Howard, H. A., mgr., Thorold Public Utilities Commission, Thorold, Ontario, Canada
Huffaker, M. F., elec. designer, Kennecott Copper Corp., Garfield, Utah
Hulsey, B. B., Jr., senior engr., Texas Electric Service Co., Fort Worth, Tex.
Hyle, S. J., technical design engr., Duquesne Light & Power Co., Pittsburgh, Pa.
Jones, J., elec. engr., Boeing Airplane Co., Seattle, Wash.
Kahler, F. C., electronic scientist, Naval Research Laboratory, Washington, D. C.
Keller, E. W., elec. engg. instructor, Massachusetts Institute of Technology, Cambridge, Mass.
Kellogg, H. L., engr., General Electric Co., Schenectady, N. Y.
Kiesling, P. W., head, planning & standards engg. div., Public Service Co. of Colorado, Denver, Colo.
Larson, H. E., application engr., steel mill div., General Electric Co., Schenectady, N. Y.
Lemire, R., chief inspector, power lines, Hydro Electric Power Commission of Ontario, Toronto, Ontario, Canada
Lithgow, E., application engr., Square D Company, Milwaukee, Wis.
Lohman, I. H., Jr., head servomechanisms engr., Emerson Electric Mfg. Co., St. Louis, Mo.
Martin, E. G., pres., Martin-Hubbard Corp., Boston, Mass.
Mason, J. W., III, application & electrical engr., Raub Supply Co., Lancaster, Pa.
Mathisen, M. E., application engr., General Electric Co., Schenectady, N. Y.
May, H. F., supervisor, government section, Teleregister Corp., New York, N. Y.
McDaniels, R. R., mgr., engg. training & standards, Kelso-Burnett Electric Co., Chicago, Ill.
Menard, G. A., vice pres. & genl. mgr., Memco Engineering & Manufacturing Co., Inc., Commack, N. Y.
Milewski, C. A., elec. engr., U. S. Army, Philadelphia, Pa.
Miller, D. R., section engr., knolls atomic power lab., General Electric Co., Schenectady, N. Y.
Moore, R. B., mgr., mining div., General Electric Co., Schenectady, N. Y.
Morgan, T. O., senior elec. engr., buick motor div., General Motors Corp., Flint, Mich.
Nelson, A., elec. engg. associate, dept. of water & power, City of Los Angeles, Calif.
Neteland, C. L., senior draftsman, Commonwealth Edison Co., Chicago, Ill.
Newton, J. P., associate professor of elec. engg., Rutgers University, New Brunswick, N. J.
Norton, F. L. W., design engr., Westinghouse Electric Corp., Sharon, Pa.
Osipovich, A. A., chief, transmission design sec., Bonneville Power Administration, Portland, Oreg.
Parker, R. J., section engr., General Electric Co., Schenectady, N. Y.
Pegnim, T. C., elec. engr., American Machine & Foundry Co., Brooklyn, N. Y.
Peterson, G. M., design engr., Boeing Airplane Co., Seattle, Wash.
Peterson, R. A., general commercial engr., West Coast Telephone Co., Everett, Wash.
Pries, L. F., teacher, New York State Agricultural & Technical Institute, Canton, N. Y.
Rademacher, L. B., design engr., Westinghouse Electric Corp., Sharon, Pa.
Rader, H. E., toll transmission engr., Pacific Telephone & Telegraph Co., Los Angeles, Calif.
Reed, A. L., asst. prof., West Virginia University, Morgantown, W. Va.
Richman, M. A., project engr., Sperry Gyroscope Co., Great Neck, N. Y.
Robb, D. D., asst. prof. of elec. engg., Iowa State College, Ames, Iowa
Rohloff, H. E., engr., The Southern New England Telephone Co., New Haven, Conn.
Rothstein, M., chief engr., thermatorn div., Radio Receptor Co., Brooklyn, N. Y.
Sampers, H. C., engr., Omaha Public Power District, Omaha, Nebr.
Sandiford, P. L., Jr., design engr., Lockheed Aircraft Corp., Burbank, Calif.
Schottler, G. J., patent lawyer, Emery, Varney, Whittemore & Dix., New York, N. Y.
Sheppard, H. H., mgr., Rumsey Electric Co., Philadelphia, Pa.
Shirland, F. A., Jr., product & process control engr., National Carbon Co., Cleveland, Ohio
Simpson, W. P., section engr., General Electric Co., Schenectady, N. Y.
Snyder, A. E., Jr., staff engr., American Viscose Corp., Roanoke, Va.
Squires, W. G., engr., electrical design div., Texas Power & Light Co., Dallas, Tex.
Stammerjohn, L. W., member of technical staff, Bell Telephone Laboratories, Murray Hill, N. J.
Stieber, T. E., mgr., central station dept., Westinghouse Electric Corp., Philadelphia, Pa.
Stoudt, J. M., engr. & chemist, Alfred LeFeber & Associates, Cincinnati, Ohio
Strachan, C. A., chief elec. engr., Blue Mountains City Council, Katoomba, Australia
Strum, F. L., lead engr., Boeing Airplane Co., Seattle, Wash.
Stubbins, W. F., physics instructor, University of Cincinnati, Ohio
Sutherland, D. J., elec. engr., Westinghouse Electric Corp., Houston, Tex.
Talcott, H. G., elec. engr., analytical research lab., Automatic Electric Co., Chicago, Ill.
Taylor, A. D., supervisor, elec. engg. section, Sandia Corp., Albuquerque, N. Mex.
Thompson, C. E., elec. engr. & estimator, Ross Electric Construction Co., Philadelphia, Pa.
Thompson, F., application engr., General Electric Co., Seattle, Wash.
Tomasso, M. C., mgr., elec. div., All State Engineering Co., Trenton, N. J.
Tremaine, R. L., central station engr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Truemner, R. O., elec. engr., Hevi Duty Electric Co., Milwaukee, Wis.
Walston, T. E., Jr., elec. engr., Consolidated Western Steel Corp., Orange, Tex.
Whitaker, H. B., senior assoc. elec. engr., Underwriters' Laboratories, Inc., Chicago, Ill.
White, M. J., engr., Pacific Electric Manufacturing Corp., San Francisco, Calif.
Willems, J. M., engr. mgr., mfgrg. & repair dept., Westinghouse Electric Corp., Pittsburgh, Pa.
Woodward, W. V., mgr., Meade Electric Co. of Indiana, Hammond, Ind.
Zehner, J. L., design engr., General Electric Co., Schenectady, N. Y.

103 to grade of Member

Applications for Election

Application for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before September 25, 1951, or November 25, 1951, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Albright, R. H., Railway & Industrial Engg. Co., Greensburg, Pa.
Allen, W., General Elec. Co., Philadelphia, Pa.
Bonch, V., Hongkong Elec. Co., Ltd., Hongkong, China
Bonn, T. H., Eckert-Mauchly Computer Corp., Philadelphia, Pa.
Chambers, F., T.V.A., Chattanooga, Tenn.
Egli, J., Canadian General Elec. Co., Davenport Works, Toronto, Ontario, Canada
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Committee on Metallic Rectifiers

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Committee on Nucleonics

W. F. Davidson, *Chairman;* Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.
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Sections

Name	District	Organized	Chairman	Secretary	Secretary's Address
Akron	2	Aug. 12, '20	R. F. Miller	P. O. Huss	University of Akron, Akron 4, Ohio
Alabama	4	May 22, '29	T. S. Birdsong	E. C. Gentle, Jr.	Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Arizona	8	Mar. 22, '41	I. G. Jenkins, Jr.	K. V. Fletcher	General Electric Co., 303 Luhrs Tower, Phoenix, Ariz.
Arkansas	7	Apr. 23, '47	R. J. Rhinehart	W. A. Bost	707 Boyle Bldg., Little Rock, Ark.
Arrowhead	5	Apr. 23, '47	Roy B. Wiprud	T. W. Holmes	4709 Gladstone St., Duluth 4, Minn.
Beaumont	7	June 27, '45	T. G. Smith	R. W. Sherwood	Gulf States Utilities Co., Beaumont, Texas
Boston	1	Feb. 13, '03	J. F. Archibald	L. J. Weed	Boston Edison Co., 39 Boylston St., Boston 11, Mass.
Canton	2	Nov. 5, '47	S. A. Langell	C. J. Muckley	5310 Hilltop Path, N. W., Canton 9, Ohio
Central Illinois	5	June 28, '51	J. F. Kruszka	C. R. Schultz	2040 North 22nd St., Springfield, Ill.
Central Indiana	5	Jan. 12, '12	C. A. Wilson	P. B. Ewing	Indiana Bell Telephone Co., Indianapolis, Ind.
Chicago	5	1893	W. M. Ballenger	R. R. O'Connor	Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.
Cincinnati	2	June 30, '20	Sheldon B. Storer	W. A. Farris	111 Farragut Road, Greenhills, Cincinnati 18, Ohio
Cleveland	2	Sept. 27, '07	C. J. Beller	L. J. Shaffer	Ohio Bell Telephone Co., 820 Superior Ave., N. W., Cleveland 13, Ohio
Columbus	2	Mar. 17, '22	C. E. Warren	A. P. Jerencsik	1487 West 7th Ave., Columbus, Ohio
Connecticut	1	Apr. 16, '21	E. G. Horton	M. B. Sprague	The Southern New England Telephone Co., 227 Church St., New Haven 6, Conn.
Dayton	2	June 9, '43	R. L. Dingle	L. H. Henry	118 Oakview Drive, Dayton 9, Ohio
Denver	6	May 18, '15	Evan R. Jones	H. F. Gidlund	Public Service Co. of Colorado, P. O. Box 840, Denver 1, Colo.
East Tennessee	4	Sept. 2, '36	F. J. Baker	W. M. Stanley	Tennessee Valley Authority, 204 Power Bldg., Chattanooga 1, Tenn.
Erie	2	Jan. 11, '18	C. B. Lewis	G. H. Ramandanes	103 East 35th St., Erie, Pa.
Florida	4	Jan. 28, '31	J. A. Turner, Sr.	B. N. Darlington	902 Peninsular St., Tampa, Fla.
Fort Wayne	5	Aug. 14, '08	R. D. Jones	M. L. Miller	526 Dayton Ave., Fort Wayne, Ind.
Georgia	4	Jan. 14, '04	H. P. Peters	W. H. Hickey, Jr.	Southern States Equipment Corp., Hampton, Ga.
Houston	7	Aug. 7, '28	W. E. Silvus	T. A. Standish	2106 Swift, Houston 5, Texas
Illinois Valley	5	June 30, '45	R. M. King	R. H. Bonney	2011 Isabell Ave., Peoria, Ill.
Iowa	5	June 29, '29	J. E. Lagerstrom	F. E. Baird	Northwestern Bell Telephone Co., 816 Telephone Bldg., Des Moines, Iowa
Ithaca	1	Oct. 15, '02	S. W. Zimmerman	E. F. Wood	1715 Lovell Terrace, Elmira, N. Y.
Kansas City	7	Apr. 14, '16	A. J. Nicholson	J. C. Bibbs	Westinghouse Electric Corp., 101 W. 11th St., Kansas City 6, Mo.
Lehigh Valley	2	Apr. 16, '21	J. O. Leslie	W. C. Seymour	Pennsylvania Power & Light Co., 117 East Broad St., Hazelton, Pa.
Los Angeles	8	May 19, '08	E. K. Sadler	C. A. Wells	Pacific Tel. & Tel. Co., 740 South Olive St., Los Angeles 55, Calif.
Louisville	4	Oct. 15, '26	W. G. Adair	J. G. Lips	Acme Contracting&Engg. Co., 120 Hillcrest Ave., Louisville 6, Ky.
Lynn	1	Aug. 22, '11	A. M. Bjontegard	E. K. Rohr	General Electric Co., 920 Western Ave., Lynn, Mass.
Madison	5	Jan. 8, '09	T. J. Higgins	N. L. Schmitz	University of Wisconsin, Madison 6, Wis.
Mansfield	2	Mar. 6, '39	F. L. Hanson	E. F. Huston	P. O. Box 431, Mansfield, Ohio
Maryland	2	Dec. 16, '04	J. W. Magee	Carl Watchorn	1611 Lexington Bldg., Baltimore 3, Md.
Memphis	4	May 22, '30	W. J. Fransioli, Jr.	V. E. Mohler	519 Williamsburg, Memphis 11, Tenn.
Mexico	7	June 29, '22	Gonzalo Fortoul	C. R. Arguelles	Palma 33, Despacho 210, Mexico D. F., Mexico
Miami	4	Feb. 3, '49	O. T. Ayers, Jr.	C. O. Grannis	1230 N. W. 57th St., Miami, Fla.
Michigan	5	Jan. 13, '11	I. B. Baccus	A. P. Fugill	Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.
Milwaukee	5	Feb. 11, '10	C. P. Feldhausen	H. C. Brem	Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
Minnesota	5	Apr. 7, '02	G. B. Germain	R. M. Kalb	4906—37th Ave., South, Minneapolis 17, Minn.
Mississippi	4	June 28, '51	W. L. Harp	T. R. Brock	General Elec. Co., 203 West Capitol St., Jackson 12, Miss.
Montana	9	June 24, '31	D. E. Kampschror	W. H. Blankmeyer	The Montana Power Co., Butte, Montana
Montreal	10	Apr. 16, '43	J. M. Sharpe	Leo Roy	2962 Fendall Ave., Montreal, Que., Canada
Nashville	4	June 28, '51	Walter Criley	J. M. Pinkerton	Nashville Electric Service, 605 Church St., Nashville, Tenn.
Nebraska	6	Jan. 21, '25	F. C. Clatterbaugh	A. G. Johnson	Omaha Public Power District, 936 Electric Bldg., Omaha, Nebr.
New Mexico-West Texas	7	Mar. 7, '40	Lee R. Hammond	R. E. Gnauck	4310 Dover St., El Paso, Texas
New Orleans	4	Dec. 8, '33	J. R. Rombach	H. E. Pritchard, Jr.	5836 General Haig St., New Orleans 19, La.
New York	3	Dec. 10, '19	J. P. Neubauer	Leland Stone	General Electric Co., 744 Broad St., Newark 2, N. J.
Niagara Frontier	1	Feb. 10, '25	J. P. Wood	T. O. Zittel	304 East & West Road, West Seneca 24, N. Y.
Niagara International	10	Aug. 5, '48	J. A. Williamson	J. A. Armstrong	112 1/2 Geneva Ave., St. Catharines, Ont., Canada
North Carolina	4	Mar. 21, '29	Ben Martin	W. C. Burnett	Southern Bell Tel & Tel. Co., 1701 Johnston Bldg., Charlotte, N.C.
Northeastern Michigan	5	Feb. 2, '50	A. E. Stevens	J. E. Young	Consumers Power Co., 600 Federal Ave., Saginaw, Mich.
Northern New Mexico	7	Jan. 25, '51	A. D. Taylor	M. L. Favia	Sandia Corp., 919 No. Jefferson, Albuquerque, New Mexico
North Texas	7	May 18, '28	E. W. Rogers	J. L. Pratt	1800 North Market St., Dallas, Texas
Oak Ridge	4	Feb. 1950	E. W. Parrish	R. B. Somers	102 Norton Road, Oak Ridge, Tenn.
Oklahoma City	7	Feb. 16, '22	J. S. Wantland	Bryce Brady	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Ottawa	10	June 23, '49	C. R. Thornton	J. Rylance	133 Russell Road, Overbrook, Ottawa, Canada
Panhandle Plains	7	June 12, '47	H. P. Mathieu	P. S. Sterrett	Southwestern Public Service Co., Clovis, New Mexico
Philadelphia	2	Feb. 18, '03	H. H. Sheppard	W. F. Denkhaus	Bell Telephone Co. of Pa., 1401 Arch St., Philadelphia, Pa.
Pittsburgh	2	Oct. 13, '02	A. A. Johnson	W. J. Lyman	435—6th Ave., Pittsburgh 19, Pa.
Pittsfield	1	Mar. 25, '04	W. E. Birchard	W. A. McMorris	95 Strong Ave., Pittsfield, Mass.
Portland	9	May 18, '09	Waldo Porter, Jr.	William G. Meyer	Westinghouse Electric Corp., 914 U. S. National Bank Bldg., Portland, 4, Oreg.
Providence	1	Mar. 12, '20	G. E. Andrews	C. B. Leathers	General Electric Co., 111 Westminster St., Providence, R. I.
Richland	9	Apr. 23, '48	R. B. Crow	E. P. Peabody	1407 Thayer, Richland, Wash.
Rochester	1	Oct. 9, '14	J. A. Gienger	R. A. Rankin	Eastman Kodak Co., Rochester, N. Y.
Rock River Valley	5	Apr. 23, '47	C. F. Vinci	V. W. Schmidt	Louis Allis Co., 121 7th St., Rockford, Ill.
Sacramento	8	June 15, '50	A. B. Johnson	A. R. Tanner	864 Robertson Way, Sacramento 18, Calif.
St. Louis	7	Jan. 14, '03	R. N. Slinger	R. C. Hase	1205 Telephone Bldg., St. Louis 1, Mo.
San Diego	8	Jan. 18, '39	O. L. Doolittle	I. E. McDougal	7560 Olive Place, La Mesa, Calif.
San Francisco	8	Dec. 23, '04	W. F. Poynter	W. R. Johnson	Pacific Gas & Elec. Co., 245 Market St., San Francisco, Calif.
Schenectady	1	Jan. 26, '03	L. T. Rader	C. C. Herskind	General Elec. Co., Schenectady 5, N. Y.
Seattle	9	Jan. 19, '04	C. D. Howe	D. E. Edwards	9402—6th Ave., S. W., Seattle 6, Wash.
Sharon	2	Dec. 11, '25	M. M. Morisuye	T. A. Casey	1527 Penn Ave., Sharpsville, Pa.
Shreveport	4	June 12, '47	E. D. Nuttall	W. C. Morris, Jr.	388 Atlantic St., Shreveport, La.
South Bend	5	Feb. 26, '41	H. R. Neighbours	J. W. Leadbetter	314 Peashway St., South Bend 17, Ind.
South Carolina	4	Mar. 2, '40	C. Y. House	G. L. Dibble	141 Meeting Street, Charlotte, S. C.
South Texas	7	May 23, '30	R. R. Krezdorn	J. C. Smith	Box 159, Route 6, Austin, Texas
Spokane	9	Feb. 14, '13	R. M. Gilbert	Charles Uhden	West 303 Joseph Ave., Spokane 12, Wash.
Springfield	1	June 29, '22	R. H. Walker	D. L. Ross	Westinghouse Elec. Corp., 26 Vernon St., Springfield 3, Mass.
Syracuse	1	Aug. 12, '20	D. A. Gaffney	A. H. Clark	202 Carleton Drive, Syracuse 3, N. Y.
Toledo	2	June 3, '07	T. J. Kozak	J. B. Cloer, Jr.	2723 Eldora Drive, Toledo 13, Ohio
Toronto	10	Sept. 30, '03	H. R. Osborne	D. N. Culver	Bell Telephone Co. of Canada, Ltd., 76 Adelaide St. West, Toronto 1, Ont., Canada
Tri-State	2	June 28, '51	C. W. Feil	Jack Steelman, Jr.	2010 Enslow Blvd., Huntington 1, W. Va.
Tulsa	7	Oct. 1, '37	W. H. Plumer	Harold Furtney	Wagner Elec. Corp., 303 Tuloma Bldg., Tulsa 3, Okla.
Utah	9	Mar. 9, '17	R. A. Radford	L. D. Harris	1738 Logan Ave., Salt Lake City, Utah
Vancouver	9	Aug. 22, '11	D. S. Smith	Maurice Shockley	Canadian General Electric Co., Ltd., 1065 West Pender St., Vancouver, B. C., Canada
Virginia	4	May 19, '22	R. B. Liverman	L. D. Johnson, III	R. F. D. 7, Box 201, Richmond, Va.
Virginia Mountain	4	June 23, '49	A. B. Tillett	H. A. Clarke	Appalachian Electric Power Co., Roanoke, Va.
Washington	2	Apr. 9, '03	F. W. Willcutt	W. J. Ellenberger	6419 Barnaby St., N. W., Washington 15, D. C.
West Virginia	2	Apr. 9, '40	H. L. Lindsey	John Vodar, Jr.	4614 Noyes Ave. S. E., Charleston, W. Va.
Wichita	7	Sept. 16, '37	Berwyn Brewer	O. R. Hantla	Kansas Gas & Elec. Co., Box 208, Wichita, Kansas
Worcester	1	Feb. 18, '20	G. R. Blake	D. J. Allia	New England Power Service Co., 66 Faraday St., Worcester, Mass.
Total Sections	92				

Subsections

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aton Rouge (New Orleans Section)	F. E. Reeves	W. S. Syrett	1366 Stephens Ave., Baton Rouge 15, La.
illings (Montana Section)	C. B. Brown	H. B. Campbell	914 Yale Avenue, Billings, Mont.
nghamton Area (Ithaca Section)	J. P. Peterson	C. J. Fitch	209 West Edward St., Endicott, N. Y.
ack Hills (Denver Section)	C. L. Gust	E. R. Shields	Homestake Mining Co., Lead, S. Dak.
oise (Utah Section)			
oulder City (Los Angeles Section)	F. A. Latham	F. G. Scussel	717 New Mexico, Boulder City, Nevada
asper, Wyo. (Denver Section)	W. D. Lawrence, Jr.	W. H. Keating	Box 340, Casper, Wyo.
entral Texas (North Texas Section)	C. B. Ingram	Lee Montgomery	2621 Lyle, Waco, Texas
entre County (Pittsburgh Section)	A. F. Lopez	D. S. Pearson	Pennsylvania State College, State College, Pa.
harleston (South Carolina Section)			
harlotte (North Carolina Section)	W. C. Burnett	C. E. Harris	Duke Power Co., Box 2178, Charlotte 1, N. C.
olumbia (South Carolina Section)	J. F. Rader, Jr.	H. G. Eidson, Jr.	Radio Station W.I.S., 1111 Bull St., Columbia 1, S. C.
orpus Christi (South Texas Section)	Thomas E. Duce	J. R. Dickey	Central Power & Light Co., Corpus Christi, Texas
astern Shore (Maryland Section)	McCoy A. Tall	E. S. Mortimer	Mt. Hermon Road, Salisbury, Md.
ureka Division (San Francisco Section)	M. D. McLellan	J. T. Morgan	Pacific Gas & Elec. Co., 318—5th St., Eureka, Calif.
ort Worth (North Texas Section)	Karl Ratliff	B. B. Hulsey, Jr.	Texas Elec. Service Co., Box 970, Fort Worth 1, Texas
ox River Valley (Milwaukee Section)	H. H. Brown	G. S. Johnson	128 Lincoln Circle, Kohler, Wis.
reeport (Houston Section)			
resno Division (San Francisco Section)	G. W. Hayden	F. S. Taylor	1050 Poplar Ave., Fresno 4, Calif.
reat Falls (Montana Section)	D. Sandell	William Sanders	Anaconda Copper Mining Co., Great Falls, Mont.
amilton (Toronto Section)	H. W. Macpherson	L. G. Stopps	Canadian Westinghouse Co., Ltd., Hamilton, Ont., Canada
ampton Roads (Virginia Section)	G. T. Strailman	L. E. Rhinesmith	1119 East Warwick Road, R. D. 1, Box 35, Hilton Village, Va.
awaii (San Francisco Section)	Herbert Heinrich	John A. Ray	Hawaiian Pineapple Co., Ltd., Honolulu, Hawaii
udson Valley Division (New York Section)	E. W. Paquin	J. R. Vogel	Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
ohnstown (Pittsburgh Section)	R. S. Bogar	G. W. Murdock	Pennsylvania Elec. Co., Johnstown, Pa.
ake Charles (New Orleans Section)	S. L. Adams	J. H. Ware, Jr.	Mathieson Chemical Corp., Lake Charles, La.
ancaster-York (Maryland Section)	G. E. Conn, Jr.	K. J. Granbois	Road 2, Conestoga, Pa.
ima (Dayton Section)	F. C. Horn	E. S. Reed	Westinghouse Elec. Corp., Lima, Ohio
lid-State (North Carolina Section)	L. L. Browning, Jr.	H. M. Jackson, II	Western Electric Co., Dept. 8140, Winston-Salem, N. C.
lobile-Pensacola (Alabama Section)	W. L. Sockwell	R. E. Pride	Alabama Power Co., 68 St. Francis St., Mobile 11, Ala.
ew Hampshire (Boston Section)	P. W. Buxton	Fred Austin	Public Service Co. of N. H., 205 Main St., Nashua, N. H.
ew Jersey Division (New York Section)	J. L. Blackburn	A. G. Smith	Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
orthwest Arkansas (Arkansas Section)	R. E. Anderson	F. M. Hinkle	411 Rebecca St., Fayetteville, Ark.
uad-Cities (Iowa Section)	A. W. Kremser	G. F. Fisher	Stanley Engineering Co., Hershey Bldg., Muscatine, Iowa
acine-Kenosha (Milwaukee Section)	C. B. Lee	J. B. Winther	Dynamatic Corp., Kenosha, Wis.
ed River Valley Division (Minnesota Section)	Robert Faiman	K. B. MacKichan	2110 Second Ave. West, Grand Forks, N. Dak.
ichmond (Virginia Section)	C. E. McMurdo	D. N. Rice	P. O. Box 1194, Richmond, Va.
idgway (Erie Section)	C. F. McGinnis	J. H. Schneider	R. D. #1, Ridgway, Pa.
t. Lawrence International (Syracuse Section)	N. O. Ross	C. I. Bacon	Cornwall St. Ry. Lt. & Pr. Co., Ltd., 16 Second St. East, Cornwall, Ont., Canada
t. Maurice Valley (Montreal Section)	M. T. Ferguson	J. B. Simpson	Northern Electric Co., Ltd., 2620 Notre Dame St., Three Rivers, Que., Canada
an Jose (San Francisco Section)	A. F. Lowe	J. A. Wells	Westinghouse Elec. Corp., Sunnyvale, Calif.
avannah (Georgia Section)	J. G. Brown	J. K. Walsh	Union Bag & Paper Corp., Savannah, Ga.
hasta Division (San Francisco Section)	A. A. Craig	C. R. Machen	Pacific Gas & Elec. Co., 301 Main St., Chico, Calif.
acoma (Seattle Section)	J. J. Dempsey	E. E. Martin	City of Tacoma Light Div., Tacoma, Wash.
ampa (Florida Section)			
ancouver Island (Vancouver Section)	J. B. Hedley	O. B. Bass	747 Lampson St., Esquimalt, B. C., Canada
Vest Central Texas Division (North Texas Section)	M. E. Mullings	C. A. Glover	1926 Sycamore St., Abilene, Texas
Vest Michigan (Michigan Section)	Norman MacMillan	L. A. Zahorsky	127 Colfax St. N. E., Grand Rapids, Mich.
Vilmington (Philadelphia Section)	J. M. Rowe	R. E. Seddon	E. I. du Pont de Nemours & Co., Wilmington, Del.
anesville (Columbus Section)	R. W. Squibb	J. M. Audi	434 Sunkel Ave., Zanesville, Ohio

Geographical District Executive Committees

	District	Chairman (Vice-President, AIEE)	Secretary (District Secretary)	Chairman, District Committee on Student Activities
1	North Eastern	J. G. Tarboux, Cornell University, Ithaca, N. Y.	E. B. Alexander, New York State Elec. & Gas Corp., Binghamton, N. Y.	W. H. Erickson, Cornell University, Ithaca, N. Y.
2	Middle Eastern	J. C. Strasbourger, Cleveland Elec. Illuminating Co., 75 Public Square, Cleveland 1, Ohio	J. L. Fuller, Reliance Elec. & Engg. Co., 1088 Ivanhoe Road, Cleveland 10, Ohio	K. A. Fegley, University of Pennsylvania, 200 S. 33rd St., Philadelphia, Pa.
3	New York City	C. S. Purnell, Westinghouse Electric Corp., 40 Wall St., New York 5, N. Y.	D. W. Taylor, Public Service Elec. & Gas Co., 80 Park Place, Newark 1, N. J.	R. T. Weil, Jr., Manhattan College, New York 63, N. Y.
4	Southern	J. D. Harper, Aluminum Company of America, P. O. Box 465, Alcoa, Tenn.	C. P. Almon, Jr., Tennessee Valley Authority, Power Bldg., Chattanooga, Tenn.	D. H. Vliet, Tulane University, New Orleans 15, La.
5	Great Lakes	J. R. North, Commonwealth Services, Inc., 7 Hayes St., Jackson, Mich.	G. M. Chute, General Electric Co., 700 Antoinette St., Detroit 2, Mich.	E. A. Reid, University of Illinois, Urbana, Ill.
6	North Central	F. W. Norris, University of Nebraska, Lincoln, Nebr.	Q. L. Bonness, University of Nebraska, Lincoln, Nebr.	S. I. Pearson, University of Colorado, Boulder, Colo.
7	South West	H. R. Fritz, Southwestern Bell Tel. Co., 2502 Telephone Bldg., St. Louis 1, Mo.	R. C. Meyerand, Union Elec. Co. of Missouri, 315 No. 12th Blvd., St. Louis 1, Mo.	P. M. Honnell, Washington University, St. Louis, Mo.
8	Pacific	N. M. Lovell, Tucson Gas, Elec. Light & Power Co., Tucson, Ariz.	Fred Mahler, P. O. Drawer 869, Phoenix, Ariz.	J. C. Clark, University of Arizona, Tucson, Ariz.
9	North West	J. A. McDonald, General Electric Co., 200 So. Main St., Salt Lake City, Utah	F. O. Wald, Utah Power & Light Co., P. O. Box 899, Salt Lake City 10, Utah	L. N. Stone, Oregon State College, Corvallis, Oreg.
10	Canada	W. R. Way, Shawinigan Water & Power Co., 600 Dorchester St., West, Montreal 2, Que., Canada	L. K. Hart, Square D Co. of Canada, Ltd., 5012 Western Ave., Montreal 28, Que., Canada	

Note: Each District Executive Committee includes also the Chairmen and Secretaries of all Sections within the District, the District Vice-Chairman of the AIEE Membership Committee, and a member of the Sections Committee who is resident in the District.

Student Branches

Name and Location	District	Counselor (Member of Faculty)
*Akron, University of, Akron, Ohio	2	K. F. Sibila
Alabama Polytechnic Institute, Auburn	4	
Alabama, University of, University	4	
*Alberta, University of, Edmonton, Canada	10	
*Arizona, University of, Tucson	8	J. C. Clark
Arkansas, University of, Fayetteville	7	Ross Lanier
*British Columbia, University of, Vancouver, Canada	9	S. C. Morgan
Brooklyn, Polytechnic Institute of, Brooklyn, N. Y., (Day)	3	F. A. [illegible]
Brooklyn, Polytechnic Institute of, Brooklyn, N. Y., (Evening)	3	Anthony B. Giordano
Brown University, Providence, R. I.	1	M. F. Gordon
*Bucknell University, Lewisburg, Pa.	2	B. H. Bueffel, Jr.
California Institute of Technology, Pasadena	8	Gilbert D. McCann
*California, University of, Berkeley	8	Darrel J. Monson
*Carnegie Institute of Technology, Pittsburgh, Pa.	2	George H. Royer
Case Institute of Technology, Cleveland, Ohio	2	William A. Thomas
Catholic University of America, Washington, D. C.	2	Joseph C. Michalowicz
Cincinnati, University of, Cincinnati, Ohio	2	A. C. Herweh
Clarkson College of Technology, Potsdam, N. Y.	1	J. P. McCormick
Clemson A & M College, Clemson, S. C.	4	
Colorado A & M College, Fort Collins	6	C. C. Britton
*Colorado, University of, Boulder	6	S. I. Pearson
*Columbia University, New York, N. Y.	3	Walter A. LaPierre
*Connecticut, University of, Storrs	1	Howard L. Heydt
*Cooper Union, New York, N. Y.	3	E. W. Starr
*Cornell University, Ithaca, N. Y.	1	W. H. Erickson
*Delaware, University of, Newark	2	H. S. Bueche
*Denver, University of, Denver, Colo.	6	A. M. Stiles
*Detroit, University of, Detroit, Mich.	5	Guido Ferrara
*Drexel Institute of Technology, Philadelphia	2	F. C. Powell
Duke University, Durham, N. C.	4	
Fenn College, Cleveland, Ohio	2	R. W. Schindler
*Florida, University of, Gainesville	4	
George Washington University, Washington, D. C.	2	Jerome S. Antel, Jr.
Georgia Institute of Technology, Atlanta	4	
Harvard University, Cambridge, Mass.	1	Kenneth Johansen
Howard University, Washington, D. C.	2	E. R. Welch
Idaho, University of, Moscow	9	J. Hugo Johnson
Illinois Institute of Technology, Chicago	5	E. T. B. Gross
*Illinois, University of, Urbana, and Chicago Division, Chicago	5	E. A. Reid
*Iowa State College, Ames	5	G. A. Richardson
Iowa, University of, Iowa City	5	E. B. Kurtz
*Johns Hopkins University, Baltimore, Md.	2	John M. Kopper
Kansas State College, Manhattan	7	Earl L. Sitz
*Kansas, University of, Lawrence	7	W. P. Smith
Kentucky, University of, Lexington	4	Gustavus E. Smith
*Lafayette College, Easton, Pa.	2	J. G. Reifsnyder
Lehigh University, Bethlehem, Pa.	2	H. T. MacFarland
Louisiana Polytechnic Institute, Ruston	7	S. P. Gullatt, Jr.
*Louisiana State University, Baton Rouge	4	A. K. Ramsey
Louisville, University of, Louisville, Ky.	4	Thomas R. Bailey
*Maine, University of, Orono	1	P. M. Seal
*Manhattan College, New York, N. Y.	3	
*Marquette University, Milwaukee, Wis.	5	E. W. Kane
*Maryland, University of, College Park	2	L. J. Hodgins
*Massachusetts Institute of Technology, Cambridge	1	Alexander Kusko
Massachusetts, University of, Amherst	1	
*Michigan College of Mining and Technology, Houghton	5	G. W. Swenson
Michigan State College, East Lansing	5	Thomas W. Culpepper
*Michigan, University of, Ann Arbor	5	John J. Carey
Milwaukee School of Engineering, Milwaukee, Wis.	5	R. J. Ungrodt
*Minnesota, University of, Minneapolis	5	Paul A. Cartwright
Mississippi State College, State College	4	
*Missouri School of Mines and Metallurgy, Rolla	7	J. W. Rittenhouse
*Missouri, University of, Columbia	7	G. V. Lago
Montana State College, Bozeman	9	E. W. Schilling
*Nebraska, University of, Lincoln	6	E. J. Ballard, Jr.
Nevada, University of, Reno	8	Harold J. Hendriks
Newark College of Engineering, Newark, N. J.	3	Robert E. Anderson
*New Hampshire, University of, Durham	1	John B. Hraba
*New Mexico College of A & M Arts, State College	7	C. D. Crosno
*New Mexico, University of, Albuquerque	7	J. L. Ellis
New York, College of the City of, New York	3	Harold Wolf
*New York University, New York	3	B. James Ley
North Carolina State College, Raleigh	4	
North Dakota Agricultural College, Fargo	5	E. M. Anderson
*North Dakota, University of, Grand Forks	5	Raymond A. Berg
*Northeastern University, Boston, Mass.	1	Roland G. Porter
*Northwestern University, Evanston, Ill.	5	A. H. Wing
Norwich University, Northfield, Vt.	1	D. B. Staake
*Notre Dame, University of, Notre Dame, Ind.	5	L. F. Stauder
Ohio Northern University, Ada	2	
*Ohio State University, Columbus	2	F. C. Weimer
*Ohio University, Athens	2	D. B. Green
*Oklahoma A & M College, Stillwater	7	David L. Johnson
*Oklahoma, University of, Norman	7	J. Bruce Wiley
*Oregon State College, Corvallis	9	L. N. Stone
*Pennsylvania State College, State College	2	A. P. Powell
*Pennsylvania, University of, Philadelphia	2	Kenneth A. Fegley
Pittsburgh, University of, Pittsburgh	2	R. C. Gorham
*Pratt Institute, Brooklyn, N. Y.	3	
*Princeton University, Princeton, N. J.	2	C. H. Willis
Puerto Rico, University of, Mayaguez	3	Jose Luis Garcia de Quevedo
Purdue University, Lafayette, Ind.	5	Stephen Freeman, Jr.
*Rensselaer Polytechnic Institute, Troy, N. Y.	1	
*Rhode Island, University of, Kingston	1	Robert S. Haas
Rice Institute, Houston, Texas	7	J. S. Waters
Rose Polytechnic Institute, Terre Haute, Ind.	5	R. D. Strum
*Rutgers University, New Brunswick, N. J.	3	H. T. Rights
Santa Clara, University of, Santa Clara, Calif.	8	Henry P. Nettesheim
South Carolina, University of, Columbia	4	
South Dakota School of Mines and Technology, Rapid City	6	J. O. Kammerman
South Dakota State College, Brookings	5	John N. Cheadle
*Southern California, University of, Los Angeles	8	Rodney C. Lewis
*Southern Methodist University, Dallas, Texas	7	F. W. Tatum
*Stanford University, Stanford, Calif.	8	W. G. Hoover
Stevens Institute of Technology, Hoboken, N. J.	3	William L. Sullivan
Swarthmore College, Swarthmore, Pa.	2	R. W. Merriam
*Syracuse University, Syracuse, N. Y.	1	
Tennessee, University of, Knoxville	4	
*Texas, A & M College of, College Station	7	N. F. Rode
*Texas Technological College, Lubbock	7	V. D. Wade
*Texas, University of, Austin, and Texas Western College Sub-Branch, El Paso	7	William J. McKune
*Toledo, University of, Toledo, Ohio	2	Tsute Yang
Toronto, University of, Toronto, Ont., Canada	10	
*Tufts College, Medford, Mass.	1	J. L. Warner
*Tulane University, New Orleans, La.	4	
Union College, Schenectady, N. Y.	1	Owen G. Owens
United States Naval Academy, Annapolis, Md.	2	D. G. Howard
*Utah, University of, Salt Lake City	9	Seymour B. Hammond
Vanderbilt University, Nashville, Tenn.	4	
Vermont, University of, Burlington	1	R. F. Mosher
Villanova College, Villanova, Pa.	2	John B. Clothier
Virginia Military Institute, Lexington, Va.	4	
Virginia Polytechnic Institute, Blacksburg	4	
*Virginia, University of, Charlottesville	4	
Washington, State College of, Pullman	9	O. E. Osburn
*Washington, University of, Seattle	9	H. M. Rustebakke
Washington University, St. Louis, Mo.	7	Pierre M. Honnell
*Wayne University, Detroit, Mich.	5	Edward L. Fairchild
West Virginia University, Morgantown	2	Everette C. Dubbe
Wisconsin, University of, Madison	5	John Baird
*Worcester Polytechnic Institute, Worcester, Mass.	1	
*Wyoming, University of, Laramie	6	R. K. Beach
*Yale University, New Haven, Conn.	1	R. R. Shank
Total Branches 133		

*Joint AIEE-IRE Branches.

AMENDMENTS TO AIEE CONSTITUTION

At the Annual Meeting of the Institute on June 25, 1951, at the Summer General Meeting in Toronto, it was an-
ounced that the membership had voted to adopt the amendments to the Constitution which the Board of Directors
ad recommended on January 25, 1951. The results of this vote will be found in the report of the Annual Meeting
n page 724 of the August issue of *Electrical Engineering*. Below will be found the former sections of the Constitution in the
eft-hand columns and the amended sections in the opposite columns.

These constitutional amendments were effective July 25, 1951, thirty days after the Annual Meeting when their
doption was announced. The new application forms for membership and transfer are available, as announced in the
ugust issue of *Electrical Engineering*, page 711.

ARTICLE II

MEMBERSHIP

FORMER

3. The corporate membership of the Institute shall consist of
Honorary Members, Fellows, Members, and Associates. Fellows,
Members, and Associates shall be equally entitled to all the rights
and privileges of the Institute, excepting that Fellows only shall be
eligible to the office of President; and Fellows and Members only
shall be eligible to the offices of Vice-President, Director, and
Treasurer. Fellows and Members shall be entitled to a diploma.
Honorary Members shall be entitled to all the rights and privileges of
the Institute.

AMENDED

3. The membership of the Institute shall consist of Honorary Members, Fellows, Members, and Associate Members, who shall be known as Corporate Members, and Affiliates, who shall be known as Non-Corporate Members. Fellows, Members, and Associate Members shall be equally entitled to all the rights and privileges of the Institute, excepting that Fellows only shall be eligible to the office of President; and Fellows and Members only shall be eligible to the offices of Vice-President, Director, and Treasurer. Members shall be entitled to a diploma and when awarded the grade of Fellow shall receive a citation. Affiliates shall be nonvoting (except for Section officers) but entitled to all other rights and privileges except holding offices reserved to Fellows and Members. Honorary Members shall be entitled to the rights and privileges of the Institute other than holding office therein.

FORMER

4. A Fellow shall be not less than thirty-two years of age and
shall qualify under one or more of paragraphs "a" to "e" of this
Section. To qualify under paragraphs "a," "b," or "c" he shall
have been in good standing in the grade of Member for a period of
at least five years immediately preceding the date of application for
the Fellow grade.

a. An electrical engineer by profession. As such he shall be
qualified to design and to take responsible charge of important electrical work; he shall have been in the active practice of his profession for at least ten years, and shall have had responsible charge
of important electrical work for at least three years. When the
applicant holds, in a principal national society of an allied branch
of engineering, membership of a grade for which the qualifications
indicate a standing equal to that required for the grade of Fellow
herein, such membership shall be considered equivalent to five of
the requisite ten years of active practice of the electrical profession.

b. A professor of electrical engineering or of electrical science.
As such he shall have attained special distinction as an expounder
of the principles of electrical science and of electrical engineering;
he shall have had at least ten years' experience as a teacher of electrical
subjects, and shall have had responsible charge for three years in
an electrical course of a principal school of engineering. Any years
of experience as defined in paragraph "a" that the applicant may have
had as an electrical engineer shall be considered the equivalent of
the same number of years of experience as "a teacher of electrical
subjects."

c. A person regularly engaged in electrical work for at least ten
years, who by training, experience, and proficiency in electrical
practice or theory has attained a standing in the profession equivalent
to that required for Fellows under paragraph "a" or "b."

d. A person who has done notable original work in electrical
science of a character to give him a recognized standing equivalent
to that required for Fellows under paragraph "a" or "b."

e. A person who holds in a principal national electrical engineering society of some other country membership of a grade for
which the qualifications indicate a standing equivalent to that required for the grade of Fellow under paragraph "a" or "b."

AMENDED

4. A Fellow shall at the time of transfer be at least 40 years of age and shall be a Member actively engaged in the electrical field (temporary unemployment excepted). He shall have had at least 15 years of active experience and shall have been in good standing in Member grade for at least 10 consecutive years immediately prior to the date of proposal for transfer to Fellow and shall qualify under paragraph "a" or "b" of this section. A person who at the time of admission to the grade of Member held membership in good standing in the principal national electrical engineering society of some other country, of a grade for which the qualifications indicate a standing equivalent to that required for the grade at Member herein, may have such years of prior membership in that equivalent grade to a maximum of nine considered as a part of the requisite ten years in Member grade.

a. He shall have attained distinction in the design, construction, manufacture, or operation of important electrical work or products or in the teaching of a major course in electrical engineering or science in an educational institution whose curriculum is approved by the Board of Directors, and as a measure of such accomplishment he shall have been in responsible charge of such work for at least five years.

b. He shall have attained distinction by reason of inventions, original work in electrical science, arts, or literature, or as an engineering executive of electrical engineering work of large scope, or the application of electricity to important engineering projects.

FORMER

5. A Member shall be not less than twenty-seven years of age, and shall be either:

a. An electrical engineer by profession. As such, under general direction, he shall have designed and taken responsibility for important electrical engineering work; he shall have been in the active practice of his profession for at least five years.

When the applicant holds, in a principal national society of an allied branch of engineering, membership of a grade for which the qualifications indicate a standing equal to that required for the grade of Member herein, such membership shall be considered equivalent to two and one-half years of the requisite five years in active practice of the electrical profession.

b. A teacher of electrical engineering or of electrical science. As such, under general direction, he shall have taken responsibility for instruction in electrical subjects in a school of recognized standing; he shall have been in the active practice of his profession for at least five years. Any years of experience as defined in paragraph "a" that the applicant may have had as an electrical engineer shall be considered the equivalent of the same number of years of experience as "a teacher of electrical subjects."

c. A person regularly employed in electrical or closely allied work for at least five years who, by inventions or by proficiency in electrical science, the electrical arts, or electrical literature, or as an executive of an electrical enterprise of large scope, has attained a standing equivalent to that required for Members under paragraphs "a" and "b." In the case of such an executive the applicant must be qualified to take responsible charge of the broader features of electrical engineering involved in the work under his direction.

6. An Associate shall be not less than twenty-one years of age and shall be either:

a. An electrical engineer by profession.

b. A teacher of electrical subjects.

c. A person who is qualified to fill a subordinate position in engineering work, or who is identified, in a responsible capacity, with an electrical enterprise.

7. In all cases, graduation from the electrical course of a school of engineering of recognized standing shall be considered the equivalent of one year's electrical experience.

8. Honorary Members may be chosen from among those who have rendered acknowledged eminent service to electrical engineering or its allied sciences.

AMENDED

5. At the time of application for admission or transfer to the grade of Member the applicant shall be at least 30 years of age and engaged in active practice in the electrical field (temporary unemployment excepted). He shall have had at least seven years of active practice of the profession in one or a combination of several branches of the electrical field, indicative of growth in competency and achievement in that field and of a character satisfactory to the Board of Directors. Graduation in an engineering curriculum of an educational institution approved by the Board of Directors shall constitute one year of this requisite of seven years and possession of a license as a Professional Engineer issued by a legally constituted Board whose requirements for licensing are considered adequate by the Board of Directors shall be considered equivalent to three years of the requisite seven years of practice. In addition he shall qualify under one or more of paragraphs "a" to "d" of this Section. To qualify under paragraphs "a," "b," or "c" he shall have been in good standing in the grade of Associate Member for a period of at least two consecutive years immediately prior to the date of application for the grade of Member.

a. An electrical engineer by profession. As such he shall be qualified to design, construct, manufacture, or operate important electrical work and shall have had responsible charge of the design, construction, manufacture, or operation of important electrieal work for at least two years.

b. A teacher of electrical engineering or electrical science. As such he shall be capable of teaching a major course in one or more fields of electrical science or engineering and shall have had responsible charge for at least two years of an electrical course in a school of electrical engineering or allied science approved by the Board of Directors.

c. A person working in the field of electrical engineering or electrical science who, by inventions, original work, or by proficiency in electrical science, the electrical arts, or electrical literature or as an engineering executive of an electrical enterprise of large scope or the application of electricity to engineering projects, has attained a standing equivalent to that required for Member grade under paragraphs "a" or "b."

d. A person who holds in good standing in a principal national engineering society of some other country membership of a grade for which the qualifications indicate a standing equivalent to that required for Member grade under paragraphs "a" or "b."

6. At the time of his application for admission or advancement to the grade of Associate Member the applicant shall be at least 21 years of age and shall be: (1) A graduate of an engineering curriculum that is approved by the Board of Directors or (2) if not such a graduate he shall have equivalent attainments, including five years of increasingly important engineering experience indicative of growth in engineering competence and achievement and of a character satisfactory to the Board of Directors. He shall be either:

a. An electrical engineer by profession. As such he shall be qualified under instruction and supervision to design, construct, manufacture, or operate electrical products or installations.

b. A teacher of electrical subjects. He shall under supervision teach subjects required in a curriculum approved by the Board of Directors.

7. At the time of application for admission to the grade of Affiliate a person shall be at least 21 years of age and shall satisfy the Board of Directors that he is interested in rendering service to electrical engineering or electrical science in the fields of commerce, industry, law, science, or the arts, or is so connected with the applications of electricity that his admission as an Affiliate would contribute to the interests of the Institute.

Delete this section.

9. Honorary Members may be chosen from among those who have rendered acknowledged eminent service to mankind in engineering or other fields.

ARTICLE III

ADMISSION, TRANSFER, AND EXPULSION OF MEMBERS

FORMER

10. Except as otherwise provided in this Article, application may be made for admission to any grade of membership, and applicants shall give references to members of the Institute as follows:

For the grade of Fellow, to five Fellows.

For the grade of Member, to four Fellows or Members.

For the grade of Associate, to three Fellows, Members, or Associates.

Applications for transfer to the grade of Fellow shall result only from a proposal of five Fellows. Applications originating from proposals shall comply with the regulations covering admission and transfer as specified in the By-laws.

Application may be made for transfer from the grade of Associate to the grade of Member.

Should an applicant for admission or transfer certify that he is not personally known to the above specified number of Fellows, Members, or Associates who are sufficiently familiar with the applicant's experience to justify him in using their names as references, the Board of Examiners may accept, for the deficiency, other references, preferably engineers of standing in the profession.

AMENDED

11. Fellow grade of membership shall be conferred by action of the Board of Directors on those members of ten years' good standing in Member grade whose outstanding work in electrical science or electrical engineering in any field is brought to the attention of the Board by five or more Fellows or Members who shall submit data that in the opinion of the Board is sufficient to substantiate the importance of the accomplishment and warrant the issuance of the citation and conferring of the honor. Transfer to Fellow may not be obtained by application.

12. Except as otherwise provided in this Article, applicants for admission or transfer to any grade of membership shall give reference as follows:

For the grade of Member, five Fellows or Members.

For the grade of Associate Member, four Fellows, Members, or Associate Members.

For the grade of Affiliate, three Fellows, Members, Associate Members, or Affiliates.

Application may be made for transfer from the grade of Associate Member to the grade of Member.

Application may be made for transfer from the grade of Affiliate to the grade of Associate Member.

Should an applicant for admission or transfer certify that he is not personally known to the above specified number of Fellows, Members, or Associate Members who are sufficiently familiar with the applicant's experience to justify him in using their names as references, the Board of Examiners may accept, for the deficiency, other references, preferably engineers of standing in the profession.

ARTICLE IV

DUES

FORMER

16. The entrance and transfer fees, payable on admission to the Institute, or upon transfer, shall be as follows:

Admission to the grade of Fellow, twenty (20) dollars.
Admission to the grade of Member, fifteen (15) dollars.
Admission to the grade of Associate, ten (10) dollars.

The transfer fee from one grade of membership to another shall be the difference between the corresponding admission fees. Persons admitted to the Associate grade, upon the expiration of their term of Student enrollment, shall not be required to pay the entrance fee. Student members of other engineering societies may be similarly admitted to Associate membership under conditions set forth in the By-laws.

17. The annual dues shall be as follows:

For Fellows, twenty (20) dollars.
For Members, fifteen (15) dollars.
For Associates, ten (10) dollars for the first six years of membership as an Associate; thereafter fifteen (15) dollars.

AMENDED

Sections 16 and 17 are now transferred to the Bylaws; see Section 18 below. (Note: The admission fee to the grade of Affiliate is to be ten (10) dollars and the annual dues of this grade is to be fifteen (15) dollars.)

18. The entrance and transfer fees, and the annual dues shall be as prescribed in the Bylaws.

The changes in the following sections are indicated as follows: where one or more words are deleted, they are *italicized* and enclosed in parentheses; words which are added are in **boldface type**. In those instances wherein the section numbers are changed, the former number is italicized and enclosed in parenthesis, as (*15*); the new section number is in boldface type, as **17**.

ARTICLE III

(*15.*) **17.** Upon the written request of ten or more Fellows, Members, or (*Associates*) **Associate Members** that, for cause stated therein, a Fellow, Member, (*or*) Associate **Member or Affiliate** of the Institute be expelled, the Board of Directors shall consider the matter and, if there appears to be sufficient reason, shall notify the accused of the charges against him, by mailing a communication to the address of the accused as it appears in the Institute records. He shall then have the right to present a written defense, and to appear for trial, in person or by duly authorized representative, before a meeting of the Board of Directors, of which meeting he shall be notified at least twenty days in advance. Not less than two months after such meeting, the Board of Directors shall finally consider the case, and if in the opinion of the Board of Directors the charges have been sustained, the accused may be expelled or suspended for such period as the Board may determine, or he may be permitted to resign.

ARTICLE IV

21. A Fellow, Member, (*or Associate*) **Associate Member, or Affiliate** who is in arrears for one year for all or any part of his dues, may be dropped from membership, as delinquent, by the Board of Directors. A Fellow, Member, (*or Associate*) **Associate Member, or Affiliate** who has been dropped as delinquent, may be reinstated upon payment of all back dues under the conditions specified in the By-laws.

22. The Board of Directors, under the conditions specified in the By-laws, may exempt from future annual dues any Fellow, Member, (*or Associate*) **Associate Member, or Affiliate** who has paid dues for thirty-five (35) years, or who shall have reached the age of seventy (70) after having paid dues for thirty (30) years.

The Board of Directors may, in its discretion, remit the dues of any Fellow, Member, (*or Associate*) **Associate Member, or Affiliate** whose name has been upon the membership list for a long term of years.

ARTICLE VI

ELECTION OF OFFICERS

(*31.*) **32.** Independent nominations may be made by a petition of twenty-five (25) or more **corporate** members sent to the Secretary when and as provided in the By-laws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

(*33.*) **34.** The President, during the month of May, shall appoint, subject to the approval of the Board of Directors, seven Fellows, Members, or (*Associates*) **Associate Members,** not members of the Board of Directors or of the Nominating Committee, to constitute the Committee of Tellers. Any Fellow, Member, or Associate **Member** not a member of the Board of Directors or of the Nominating Committee who shall deliver to the Secretary, on or before the first day of May, a written petition signed by at least twenty Fellows, Members, or (*Associates*) **Associate Members** stating their desire that he be a member of the Committee of Tellers, shall also be a member of that committee, provided that the aforesaid signatures shall not have appeared on another similar petition.

ARTICLE VII

MANAGEMENT, DUTIES OF OFFICERS AND COMMITTEES

(*37.*) **38.** The Board of Directors shall direct the investment and care of the funds of the Institute, shall make appropriations for specific purposes, shall pass upon all applications for admission or for transfer, shall act upon all questions of expulsion of members, shall appoint all employees and fix their salaries, and in general shall direct the business of the Institute, either itself or through its officers and committees. The Board of Directors at its first meeting in each fiscal year shall appoint a **corporate** member of any grade to serve as Secretary of the Institute for one year, commencing on the first of August next succeeding, subject to removal only by an affirmative vote of a majority of the members of the Board. The Secretary shall receive a salary fixed by the Board. He shall take part in the deliberations of the Board but shall not have a vote therein.

(*38.*) **39.** The Board of Directors shall prepare and adopt a series of By-laws (*which shall govern its procedure and that of the committees*), under this Constitution. Such By-laws shall be adopted or may be amended by a concurring vote of not less than a majority of the Board of Directors; provided, that the text of a proposed By-law or amendment shall be furnished to each member of the Board of Directors at least ten days before the meeting at which a vote on the same will be taken.

ARTICLE VIII

MEETINGS

(*49.*) **50.** The Annual Meeting of the Institute shall be held in 1928 on Tuesday, June 26 (during the Annual Summer Convention), and thereafter shall be held upon such date and at such place as shall be fixed in the By-laws. At this meeting a report of the activities of the Institute for the past fiscal year shall be submitted by the Board of Directors. This report shall be verified by the Secretary and approved by the Board of Directors. It shall show the whole amount of real and personal property owned, where located, where and how invested; the amount and nature of the property acquired during the past fiscal year and the manner of its acquisition; the amount applied, appropriated, or expended during the year, and the purposes, objects, or persons to or for which such applications, appropriations, or expenditures have been made; and all other essential facts bearing upon the status of the Institute. This report shall be filed with the records of the Institute and an abstract thereof entered in the minutes of the Annual Meeting. The vote for officers and Directors for the ensuing year shall be announced; and any other business may be brought before, and transacted at, this meeting. Notice of the Annual Meeting shall be sent by mail or otherwise to all Fellows, Members, (*and Associates*) **Associate Members, and Affiliates** at least ten days in advance.

(*51.*) **52.** Except as otherwise provided by law or by the Constitution, special meetings of the Institute for the transactions of business may be called by the Board of Directors at any time, by written notice stating the specific object thereof, mailed to each Fellow, Member, (*and*) Associate **Member, and Affiliate** at least ten (10) days prior to the date of said meeting.

ARTICLE IX

INSTITUTE SECTIONS AND BRANCHES

(*54.*) **55.** Whenever, in the judgment of the Board of Directors, a sufficient number of Fellows, Members, and (*Associates*) **Associate Members** shall petition, in writing, these members may form, subject to the Constitution and all By-laws and regulations which may be hereafter prescribed by the Board of Directors, a Section organization for the purpose of more effectually carrying out the aims of the Institute.

(*55.*) **56.** Any Fellow, Member, (*or*) Associate **Member, or Affiliate** may become a member of such Section, but a Fellow, Member, (*or*) Associate **Member, or Affiliate** shall be entitled to vote, or hold office, in one Section only.

(*56.*) **57.** The officers of each Section shall consist of a chairman, a secretary, and such other officers as each Section may find desirable. These officers shall be elected by the votes of the Fellows, Members, (*and Associates*) **Associate Members, and Affiliates** of the Section, in the manner provided in the Section By-laws. The election of any Fellow, Member, (*or Associate*) **Associate Member, or Affiliate** as a Section officer shall not debar him from election or appointment to any other office in the Institute.

ARTICLE X

GENERAL

(*64.*) **65.** A quorum at the Annual Meeting, or at any special business meeting, present in person or by proxy, shall consist of not less than one hundred (100) **corporate** members.

(*65.*) **66.** Every Fellow, Member, or Associate **Member** entitled to vote at any meeting may so vote by proxy, signed by the Fellow, Member, or Associate **Member** and filed with the Secretary before the meeting at which it is to be voted. No proxy shall be valid after the expiration of eleven (11) months from the date of its execution, unless the Fellow, Member, or Associate **Member** executing it shall have specified therein the length of time it is to continue in force, which shall be for some limited period. Every proxy shall be revocable at the pleasure of the person executing it.

ARTICLE XI

AMENDMENTS

(*67.*) **68.** Amendments to this Constitution may be proposed by means of a petition signed by not less than one hundred (100) Fellows, Members, or (*Associates*) **Associate Members** and received by the Secretary not later than February first; or by means of a Resolution adopted by the Board of Directors not later than February first. Such proposed amendment or amendments shall be submitted to legal counsel by the Board of Directors, and if, in the opinion of such counsel, they are in accordance with the laws under which the Institute is organized, a copy shall be mailed, with a letter ballot, to each Fellow, to each Member, and to each Associate **Member,** not later than March 1.

(*68.*) **69.** Votes, to be considered, shall be written or printed and received, through the mail or otherwise, by the Secretary not later than the first day of May. The Secretary shall hand these votes unopened to the Committee of Tellers, which shall count such votes and make a sealed report to the Board of Directors in duplicate, of which one copy shall forthwith be filed with the Secretary, and of which the other copy shall remain in possession of the chairman of the committee, who shall hand this report to the presiding officer of the Annual Meeting. In the absence of this report by the chairman of the committee the Secretary shall produce the duplicate copy and hand the same to the presiding officer of the meeting. The presiding officer shall then cause the report to be read. If the total vote be not less than twenty per cent (20%) of the total corporate membership of the Institute and if seventy-five per cent (75%) or more of all the Fellows, Members, and (*Associates*) **Associate Members** voting shall declare themselves in favor of the proposed amendment or amendments, the same shall become a part of the Constitution.

(*71.*) **72.** The Secretary shall print copies of the amendments as soon as practicable after adoption, and distribute the same to Fellows, Members, and (*Associates*) **Associate Members.**

New Supervoltage Weapon Against Cancer Makes Use of Powerful Radioactive Cobalt

The powerful supervoltage rays of radio-
ctive cobalt soon will be studied as a new
id to cancer sufferers.

A special apparatus for administering the
are isotope—possibly the first unit of its
ind—will be delivered to the Oak Ridge
nstitute of Nuclear Studies (ORINS) and
1. D. Anderson Hospital by the X-Ray
Department of General Electric Company,
Milwaukee, Wis., within the next several
nonths. Located in Oak Ridge, Tenn.,
djacent to the Atomic Energy Commission
lant, ORINS will co-operate with the
1. D. Anderson Hospital of Houston, Tex.,
ffiliated with the University of Texas, in
xtensive tests on radioactive cobalt and its
ffects on cancers.

The radiation emitted by cobalt 60, as
t is known, is equivalent to the X rays
roduced by high-voltage tubes operating
t about 1,200,000 electron volts. Four
obalt wafers, each less than 1-inch square
nd less than 1/8-inch thick, are being
rradiated in the Chalk River, Canada, atomic energy reactor, for use in the new unit. The cost of an equivalent amount of radium ($26,000,000) would be several thousand times greater. (For a description of cobalt 60, see story on "Chalk River N.R.X. Nuclear Reactor" by D. G. Hurst in *Electrical Engineering*, June 1951, pages 476–8.)

While radioactive cobalt has been tested before on cancer, this has been chiefly in the form of local therapy, usually requiring surgical planting in the tissues, whereas the new apparatus will make it possible to direct the rays at sizeable areas from a distance and to reach deep or inaccessible cancers.

The cobalt 60 unit will substitute for costly radium, since it offers similar therapeutic properties, but is cheaper. With the quantities of radium normally available, if the treatment distance were increased to 50 centimeters (about 20 inches), the intensity of the radiation reaching the body would drop so low as to be biologically useless. Or, to secure the desired effectiveness of cobalt 60 with radium at this distance would involve an amount of radium whose cost would be prohibitive.

Manipulating the isotope and adapting it to easy application has posed major problems for General Electric design engineers. They have now developed a housing and an electrical-mechanical system that makes it possible for doctors and their aides to give treatments by remote control, to limit the radiation to the patient under treatment, and to return the isotope to a safe position automatically in case of power failure.

The cobalt will be encased in a housing made of a special tungsten alloy known as Hevimet, which is considerably more dense and therefore less transparent to radiation than lead. The operator, located in an adjoining room, will be protected by thick concrete walls, but will be able to see the patient through a window consisting of 15 inches of X-ray protective material.

Radioactive cobalt takes 5.3 years to lose half of its effectiveness—the rate at which it is said to "decay"—thus making it well adapted to continued use for cancer therapy without frequent correction of calculations by the physicist or radiologist.

The first cancer therapy machine in the United States to use radioactive cobalt instead of X rays or radium as the source of radiation was unveiled on July 10 and 11. Inspecting the unit are, left to right, Dr. Gilbert H. Fletcher, radiologist at the M. D. Anderson Hospital, Houston, Tex.; Dr. Marshall Brucer, Chairman, Medical Division, Oak Ridge Institute of Nuclear Studies; and Dr. E. Dale Trout, of the General Electric Company X-Ray Department

Future Meetings of Other Societies

merican Standards Association. 33rd Annual Meet-
ng. October 22–24, 1951, Waldorf Astoria Hotel,
New York, N. Y.

Compressed Air and Gas Institute. September 20–21,
951, Skytop Lodge, Skytop, Pa.

ngineers' Council for Professional Development.
9th Annual Meeting. October 19–20, 1951, Hotel
tatler, Boston, Mass.

Iydraulic Institute. September 5–7, 1951, The Drake
Iotel, Chicago, Ill.

nstrument Society of America. Sixth National In-
trument Conference and Exhibit. September 10–14,
951, Sam Houston Coliseum, Houston, Tex.

National Association of Corrosion Engineers. South
Central Region. October 18–20, 1951, Corpus Christi,
Tex.

**National Council of State Boards of Engineering
xaminers.** 30th Annual Meeting. October 21–24,
951, Hotel Statler, Boston, Mass

National Electrical Contractors Association. Annual
Convention. October 9–12, 1951, Shoreham Hotel,
Washington, D. C.

National Electronics Conference. October 22–24,
951, Edgewater Beach Hotel, Chicago, Ill.

National Farm Electrification Conference. October
–10, 1951, Hotel Gibson, Cincinnati, Ohio.

National Safety Congress and Exposition. 39th
nnual Meeting, October 8–12, 1951, Chicago, Ill.

National Standardization Conference. 2nd Annual
Conference. October 22–24, 1951, Waldorf-Astoria
Iotel, New York, N. Y.

ennsylvania Electric Association. Fall Meeting,
ransmission and Distribution Committee. October
1–12, 1951, Hotel Concord, North East, Pa.

adio Fall Meeting. Sponsored jointly by the Institute
f Radio Engineers and the Radio Television Manufac-
urers Association. October 29–31, 1951, King Ed-
vard Hotel, Toronto, Ontario, Canada.

he American Society of Mechanical Engineers.
all Meeting. September 25–28, 1951, Hotel Radis-
on, Minneapolis, Minn.

Patent Foundation Established by George Washington University Law School

A Patent Foundation for research and education in the fields of patent, trademark, copyright, and the related systems of laws has been established under a Declaration of Trust at The George Washington University Law School, Washington, D. C. The Foundation will begin its operations when, in the opinion of the University Board of Trustees, sufficient funds are accepted to establish it on a sound financial basis. Initially an annual budget of approximately $100,000 is planned, to be increased as the full scope of the Foundation's work is realized. The organizational phase of the Foundation

is being financed through a generous grant from the Alfred P. Sloane Foundation of New York City.

Coincident with this announcement was the release of a brochure entitled "The Patent Foundation in the Nation's Capital" which sets forth the purposes and objectives of the Patent Foundation. An initial distribution of 10,000 copies of this brochure is being made in the many different fields of activity which are the concern of the Foundation's objectives, such as commerce, education, science, manufacturing, finance, labor, and the professions. Support, both financial and intellectual, and co-operation from these varied fields will insure the Foundation's success.

Acceptance to serve as Honorary Members of the Foundation and as members of its Advisory Council have been received from Joseph W. Barker, President of the Research Corporation; Vannevar Bush, President of the Carnegie Institution of Washington; Cyrus S. Ching, Director of Federal Mediation and Conciliation Service; John W. Davis, nationally known lawyer; Charles F. Kettering, member of the Board of Directors of General Motors Corporation; and Max McGraw, President of McGraw Electric Company.

The Foundation is a nonprofit enterprise set up within the University under the supervision of the Dean of the Law School as a part of its research and educational facilities. Complete discretion has been given to the Board of Trustees of the University to effectuate the declared purposes of the Foundation, independent of the special interests of any group, whether political, social, or economic.

The objectives of the Foundation, as set forth in the brochure, are: "to gather and disseminate knowledge regarding the principles, the facts, and the practical operations of the patent, copyright, trademark, and related systems of laws of the United States and other countries; to convey to the public the means of understanding the relation of these systems to American industrial and social progress and the standard of living; to determine the effect of the systems on the creation of job opportunities and the rise or fall of employment; to develop with respect to industry and business a perspective of the part played by the patent and related systems in the creation of new products and industries, in the investment of capital, in community growth, in technological research, and in the economic and marketing aspects of business policies; to organize educational programs on the systems for use in courses of instruction in all stages and fields of study; to study the place and operation of the systems in relation to incentives to advance science and the arts and to rewarding creators of industrial and intellectual subject matter; to promote understanding by the legal profession of the basic principles and actual functioning of the systems as legal and social institutions, and to provide for lawyers specializing in the fields of the systems the means of intensifying their knowledge of the laws and administration of the systems, the decisions of administrative bodies and the courts thereunder, and the relation thereto of the antitrust and trade practice laws."

The American Patent Law Association has encouraged the formation of the Patent Foundation, and the purposes and objectives of the Foundation have been subsequently endorsed by the American Bar Association and its Section on Patent, Trademark, and Copyright Law, and by a majority of the patent law associations in the country.

University officials believe that this research and educational undertaking has far-reaching potentialities of importance to the technological and industrial development and hence the well-being of the United States. They believe the Patent Foundation has the opportunity to make continuing contributions to a better understanding of the functioning of the patent, copyright, trademark, and related systems of laws in our industrial structure.

New Transparent Screen for Kinescopes Promises Improved Picture Contrast

Clearer television pictures, with greater contrast between light and dark areas, are foreseen with a new transparent screen for picture tubes, developed by the Research Laboratory of the General Electric Company. The new tube is still in the developmental stage and further work will be required before it is ready for commercial use.

Since the presence of unseen ships and airplanes is shown on the screens of similar tubes in radar equipment, it is expected that this ultimately will be another application of the new screen.

Present tubes are coated inside with a powder which appears white or gray, which is the darkest that any areas on the screen can be. When looking at one with a transparent screen, however, the viewer sees through it into the dark recesses of the tube. It is this greater degree of darkness, as opposed to the relative grayness of the usual screen, that is available for producing dark areas on the screen to contrast with light areas.

The best of the new transparent screens, at present, show a yellow-orange picture. It is believed that further research will make possible a true black and white picture.

In addition to yielding more contrasting images, the transparent screen eliminates another source of blurred detail. On the present powder screen, powder particles near a bright spot pick up some of its light and reflect it to the eye, thus causing a halo around the spot. There is no such powder on the transparent screen to pick up light and cause such a halo.

Ordinarily the powder coating inside the screen is necessary to achieve a picture, the powder being caused to glow wherever it is struck by a beam of electrons.

In 1947, it was found that a transparent screen capable of glowing under the impact of electrons could be made from zinc fluoride mixed with manganese. These chemicals were heated in a vacuum so they evaporated and then condensed as a thin, transparent film on the glass to be used as the screen. Such a film is only 1/8,000-inch thick. Although such a treated screen did not stand up under use, a method of converting it was developed so that it would withstand continued electron bombardment without deterioration. After the chemical mixture is evaporated on the glass, it is heated to about 930 degrees Fahrenheit and for about 10 minutes a stream of hydrogen sulfide is passed over it. Such a treatment results in a durable, lasting screen.

A simplified method was developed of preparing such screens by passing the chemical vapors, including the zinc and manganese, over a heated glass surface in the presence of hydrogen sulfide. This method seems to offer the greatest promise for application in television sets. In addition to the complete transparency of the screen it shows high efficiency in converting the energy of the electrons into light. Screens giving a blue picture also have been obtained by this method of chemical deposition.

Dr. L. R. Koller (left), D. A. Cusano, and Dr. F. J. Studer demonstrate the transparency of the face of a new television picture tube developed in the General Electric Research Laboratory. With the new tube it is foreseen, clearer pictures may be possible, because dark areas can appear as black as the dark interior of the tube when installed in a s

RCA Color Television Field Tests Well Received in N. Y.

For a week starting July 9, daily broadcasts of the Radio Corporation of America (RCA) color television system from the experimental station KE2XJV of the National Broadcasting Company atop th

mpire State Building were picked up on 6- and 21-inch color receivers located in he Exhibition Hall in Radio City and on lack-and-white receivers throughout the ervice area of the station. Programs riginating in the National Broadcasting Company studios and outdoor scenes picked p in Palisades Park (about 8 miles distant) vere broadcast in full color; they were elected to provide a wide range of color and tudio technique as well as remote pick-ups.

Because of the compatibility of the RCA olor system with present black-and-white tandards, television set owners in the area ould see the tests in black and white on Channel 4. All such viewers were invited o report how the color transmissions compared with those regularly put on the air in lack and white together with their addresses, he size of their viewing screen, age of eceiver, type of antenna, and other data. The consensus was that the reception was xcellent in every respect. This was also rue of the audiences who witnessed the eception of the signals on the color receivers which were paired with black-and-white ets for comparison purposes.

It is planned to have public demonstraions of RCA color television in the near uture in New York and to send the color programs to other cities by radio relay tations or the coaxial cable.

Mechanicall Subscribers Paged by Radio Within 25-Mile Area

The telephone answering service has been a boon to the busy professional and business man for many years, but in New York City a new angle has been added: when the answering service takes a phone call, the absent subscriber can be paged by radio; then when he hears his code number by means of his pocket-size radio receiver, he elephones the Telanserphone company and eceives the message.

When a call is received for a subscriber o the Mechanicall service, a slide bearing his code number of three digits recorded on a length of 16-millimeter film is placed in the input circuit of the 250-watt transmitter, where a photoelectric cell transforms the ight energy into the electric energy for modulating the transmitter. This operates on a frequency of 43.58 megacycles. The machine carrying the audio-frequency slides s automatic and has a capacity of 60 slides which are put on the air within a minute.

Thus when a subscriber is away from his office and within a 25-mile radius of the entral part of Manhattan where the transmitter is located, he does not have to interrupt his indoor or outdoor recreation by telephoning the answering service unnecessarily o find out if a message has been received or him; he merely listens for a minute to he code numbers on his Aircall receiver and if he does not hear his call, he does not have to bother to telephone.

Company's Production Line Reported on by 2-Way Radio

Handie-Talkie portable radiophones are being used by the Weatherhead Company, Cleveland, Ohio, in a production control system that results in complete minute-to-minute data on all manufacturing projects being handled.

The operator of the Handie-Talkie portable radiophone stops and checks a machine's operation and reports to the production control center on the status of the parts being machined. By this means the company maintains continuous inventory of orders in production

Men with Motorola portables move along the production floor and continuously report into the control center on the activities at each production point. By the combination of these reports, plus an extensive wired intercommunications system and production control boards, the company knows immediately the status of any contract in the building. The production status of more than 2,000 key products is maintained at all times as a result of the new control methods.

Results of Two Surveys by EMC Shows Need for 60,000 Engineers

Two surveys recently conducted by the Engineering Manpower Commission (EMC) of the Engineers Joint Council (EJC) showed that there currently exists an unfilled demand for more than 60,000 engineers, exclusive of military needs, even after the 1951 graduating class is absorbed.

ONLY 19,000 GRADUATES FOR INDUSTRY

EMC, desirous of determining what proportion of the current graduating class would be taken by the armed services through the Reserve Officers Training Corps (R.O.T.C.) programs, the reserve forces, or the draft, and what proportion would be available for industry, mailed a questionnaire to the deans of the 135 engineering colleges accredited by the Engineers' Council for Professional Development. The 86 colleges answering the questions expected to graduate 18,630 engineers in June.

This represents about 50 per cent of the expected graduates. The following proportions are based upon the answers received.

To be commissioned in Armed Services or Reserves through R.O.T.C. training	11 Per Cent
Enlisted members of Reserves or National Guard	16 Per Cent
Will become draft eligible after graduation	36 Per Cent
Total available to the Armed Services	63 Per Cent

It is reasonable to expect that all of the 11 per cent to be commissioned as a result of R.O.T.C. training and possibly half of the 16 per cent who are enlisted members of the reserves or National Guard will be called to active duty promptly. Even after adjusting the estimate of 36 per cent draft eligibles to reflect the percentage of 4F's determined in studies by the United States Office of Education, those who will become draft eligible will still be about 31 per cent of this year's class. Should the Selective Service System induct the draft eligibles, and there are indications that they will make every effort to do so, there will be only about half of the 38,000 engineering graduates left to fill industrial needs. Industry can thus count on only about 19,000 engineering graduates this year. The shortage of engineers will be made even more acute by losses of existing engineers to the Armed Services. A previous survey this year showed that 25 per cent of the engineers employed in industry were enrolled in the reserves.

80,000 ENGINEERS REQUIRED

A telegraphic survey of the needs of 378 companies and government agencies for engineers and scientists was conducted by the EMC of EJC. The survey showed that about 80,000 engineers are required, exclusive of the needs of the military. When the current graduating class of 38,000 is absorbed, there is still an unfilled demand

for 42,000 engineering graduates. However, only 19,000 engineering graduates will be available for industry; thus the actual unfilled demand will be for more than 60,000 engineers.

These facts were revealed by Dean S. C. Hollister, newly elected President of the American Society for Engineering Education (ASEE), and other speakers at the 59th Annual Meeting of the ASEE June 25–29 at Michigan State College.

A summary of answers to the telegraphic survey is given here.

	Engineers Summary of answers from 378 companies and governmental agencies	Other Scientists Summary of answers from 102 companies and governmental agencies
Minimum number 1951 graduates needed	21,964	2,203
Number of acceptances received	9,838	1,188
Total number of 1950 graduates hired	12,161	1,354
Best estimate of total graduates in employ	127,972	15,888

(None of these figures include the military needs of the Department of Defense or the needs of the Atomic Energy Commission.)

Relating these figures for engineers to the total number of employed engineers in the nation and to the total numbers graduating in 1950 and 1951 indicated a total current demand for all except military needs at about 80,000. This is about 50,000 more than the previously estimated normal annual demand of 30,000 engineering graduates.

It was not possible to determine from the answers obtained whether the sharp increase in demand was due to the tooling-up needs of a partial mobilization, or because of the extreme technological advance of the past several years and the increased use of engineers and scientists by various organizations and agencies. It is believed that much of this increase may be a long-term trend.

Important Manpower Convocation in Pittsburgh, Pa., Sept. 28

The Engineering Manpower Commission (EMC) is planning an engineering manpower convocation in Pittsburgh, Pa., September 28 at the Stephen Foster Memorial Hall. The host organization will be the Engineers' Society of Western Pennsylvania. The purpose of the convocation is to inform the engineering profession about the critical shortage of engineers and the program of the EMC will be to invoke widespread co-operation in carrying out the program (see "Engineering—Its Future" by A. C. Monteith on pages 758–61 of this issue). The convocation is actually a pilot convocation at which industry and the profession in the Pittsburgh area will be represented, and to which representation from engineering groups throughout the country will be invited.

A brochure in package form containing the full talks at the convocation, plus all of the releases of EMC to date, will be available.

The active co-operation of all the local sections of the parent societies in selecting the delegations that will represent their areas is sought. This will provide the framework for local groups to have similar convocations in their areas.

The electric power unit under the nose of a United Air Lines Mainliner Stratocruiser at Honolulu, Hawaii, is one of the largest ever built for an air transport company. Delivering a maximum of 2,500 amperes, it runs the air-cooling system to keep cabins comfortable while the 71-ton, double-decked planes are on the ground loading passengers

Stratocruisers Keep Cool While Loading Passengers

One of the largest mobile electric power units ever built for an air transport company recently was placed in service at Honolulu by United Air Lines.

Maximum output of the new unit is 2,500 amperes, including overload value of 500 amperes. It is used to run the air-cooling system of Mainliner Stratocruisers, maintaining comfortable cabin temperatures while the 71-ton airliners are on the ground loading passengers. The cooling system of a Mainliner Stratocruiser is equal to the combined capacity of 300 home refrigerators.

The power plant, mounted on a truck chassis, is driven by a 145-horsepower engine. A governor permits operation at 1,500 or 2,000 amperes. The unit was built to United's specifications by the Hobart Manufacturing Company of Troy, Ohio.

Fall Meeting of URSI-IRE to Be Held at Cornell Oct. 8-10

A meeting of the United States National Committee of the International Scientific Radio Union (URSI) and the Institute of Radio Engineers (IRE) Professional Group on Antennas and Propagation is being held on the campus of Cornell University, Ithaca, N. Y., on October 8, 9, and 10. The School of Electrical Engineering will be the host.

Sessions will be held on the following topics. Papers concerning a given subject are invited and should be submitted to the individuals named.

Radio Standards and Methods of Measurement
F. J. Gaffney
Polytechnic Research and Development Co., Inc.
202 Tillary Street
Brooklyn 1, N. Y.

Tropospheric Radio Propagation
A. W. Straiton
Electrical Engineering Research Lab.
Box F, University Station, Austin 12, Tex.

Ionospheric Radio Propagation
H. G. Booker
School of Electrical Engineering
Cornell University, Ithaca, N. Y.

Extraterrestrial Radio Noise
A. H. Shapley
Central Radio Propagation Laboratory
National Bureau of Standards
Washington 25, D. C.

Circuit Theory
C. H. Page
National Bureau of Standards
Washington 25, D. C.

Electronics
J. A. Morton
Bell Telephone Laboratories
463 West Street
New York 14, N. Y.

In view of housing and other facilities available, it is very desirable for registration to be made in advance of the meeting. Advance registration cards and further information concerning the meetings may be obtained from A. H. Waynick, Secretary, U. S. A. National Committee of URSI, The Pennsylvania State College, State College, Pa.

IEE to Publish Part IV of The Proceedings and Monographs

Arrangements have been made for the publication of a new Part of *The Proceedings* of The Institution of Electrical Engineers, to be known as Part IV, which will contain papers which by the nature of their subject matter are of greater immediate importance to the engineer-scientist than to the engineer-operator and are thus of interest to only a small number of the general body of readers of Parts I, II, and III of *The Proceedings* in which such papers have hitherto appeared. This new Part will be published at intervals depending upon the flow of material but in any event not less frequently than once a year. In addition, each paper of this class will be issued separately as an *Institution Monograph* directly it has been set up in type.

The specially reduced subscription rate for members of sister Institutions for Part IV

is 7s. 6d. per annum (that is, half the published price). To those members who subscribe also to Parts I, II, and III and wish to take Part IV, the combined subscription for all four Parts as from January 1, 1952, will be £2.10.0d. per annum. Those who have already subscribed for Parts I, II, and III for this year can obtain Part IV on payment of the additional amount of 7s. 6d.

With regard to *Institution Monographs*, as these will be in the nature of separate advance copies of the papers that will eventually appear in Part IV, they can be supplied only at the full advertised price of 1s.3d. each and a separate application to the office of The Institution of Electrical Engineers in London, England, is necessary in each case. Announcements of the availability of Monographs will be made from time to time in a leaflet which will be enclosed with the Parts of *The Proceedings*.

International Commission on Illumination Meets in Stockholm

At Session XII of the International Commission on Illumination held in Stockholm, Sweden, June 26 to July 7, 1951, Dr. Ward Harrison of the United States was elected President of the Commission for the 4-year period ending in 1955, when Session XIII will be held in Switzerland. Dr. Harrison was formerly Head of the Engineering Division, Lamp Department, General Electric Company, Nela Park, Cleveland, Ohio, and is now retired.

Other officers elected were: N. A. Halbertsma (Netherlands), Honorary President; J. W. T. Walsh (Great Britain), Vice-President; M. Leblanc (France), Vice-President; I. Folcker (Sweden), Vice-President; H. König (Switzerland), Honorary Treasurer; and C. A. Atherton (United States), Honorary Secretary.

At the opening general session, in the presence of King Gustav VI Adolf, 450 delegates from 22 countries, and 100 guests, a paper by Mr. Ralph Evans, Eastman Kodak Company, on "Seeing, Light, and Color" was presented by Dr. D. B. Judd, National Bureau of Standards.

Following the opening session, parallel sessions were held by the 25 Technical Committees of the Commission. Each of these committees presented a technical report for discussion. In addition, 43 papers were presented at the sessions. Five of the Technical Committee Reports were compiled by United States Secretariat Directors, and six of the papers were of United States origin. These are as follows:

- Colorimetry, D. B. Judd, Secretariat Director, *TC-7*
- Lighting of Public Highways, R. M. Zabel, Secretariat Director, *TC-23a*
- Colors of Light Signals, F. C. Breckenridge, Secretariat Director, *TC-26e*
- Lighting Practice, W. C. Brown, Secretariat Director, *TC-62b*
- Television, H. A. Kliegel, Secretariat Director, *TC-63*
- The Engineering Evolution of the Fluorescent Lamp, D. F. Lowry
- The Subjective Appraisal of Brightness, S. K. Guth
- Daylight in Classrooms, R. L. Biesele
- Two Decades of Residential Lighting in the United States, M. Fahsbender (the first American woman to present a paper before the Commission).
- Space Concepts of Lighting, R. G. Slauer
- Creating a Selling Environment with Light, C. M. Cutler

The sessions were too preoccupied with technical activity to permit of partaking in many of the attractive diversions which beautiful Stockholm had to offer in the first two weeks of summer. However, the delegates did participate in these entertainment features during available evenings: informal reception and concert at the National Gallery of Art; supper-dance at the Grand Hotel Saltsjöbaden; dinner in the Gold Room of City Hall; music and ballet at Old Drottningholm Theater; and a boat ride in Stockholm Archipelago.

The results of the work transacted at the technical sessions will be published in a 3-volume Proceedings.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Aluminum Conductors for Aircraft

To the Editor:

The Letter to the Editor by B. E. Noltingk and E. A. Neppiras (*EE, July '51, pp 654–5*) may tend to leave two erroneous impressions in the minds of some readers.

First, the letter implies that compression joints made on aluminum conductors, such as described by W. W. Schumacher in the December 1950 issue of *Electrical Engineering*, are difficult to apply, and that their application is critical.

Second, it would appear from the example given in the letter that the resistance of clamp joints on aluminum conductors is many times greater than that of compression, or solder, joints.

In view of the large and ever-increasing number of electric connections made on aluminum conductors in aircraft, it seems desirable to correct this misconception.

Granted that the resistance of a properly soldered aluminum aircraft terminal joint is no greater than the resistance of an equal length of cable, the same is true of a properly made compression joint. However, the compression joint has the following obvious advantages over the solder joint.

1. The compression joint does not require any preparation of the cable, except removal of the insulation.
2. The compression joint can be, and is being, installed by means of portable tools in the field. Field installation of ultrasonic soldered joints seems virtually impossible.
3. The compression joint is foolproof. If indented to the proper depth, there can be no doubt about the soundness of the connection. Positive inspection of a soldered connection is quite difficult.
4. A compression joint is not affected by vibration. In a soldered joint, the portion of the conductor adjacent to the terminal is stiff, and not flexible. This is an undesirable condition in view of possible vibration fatigue failures.
5. A compression joint does not require the use of fairly large amounts of critical materials, such as tin contained in the solder.
6. It seems obvious that application of compression joints is much faster, and therefore cheaper, than the making of a good solder joint. This economic advantage is even greater when considering the necessary preparation of the aluminum conductors for soldering, plus the cost of the solder.

As to the high resistance of the clamp joint mentioned by Mr. Noltingk and Mr. Neppiras, I would not consider a joint with a resistance of 1,000 microhms on a cable of between 2/0 and 3/0 American Wire Gauge in size an electric connection at all. Assuming a joint length of 1 inch, such a resistance would equal a relative conductivity of approximately 1 per cent. It is apparent that the clamp joint referred to in the letter was not made properly. Using a clamp-type connector correctly designed for aluminum, and a joint compound, such as Penetrox, there is no reason whatsoever why the joint resistance of such a connection on aluminum conductors should be any higher than the resistance of a compression, or for that matter, a solder joint. For the example given, this resistance should be approximately 10 microhms.

W. F. BONWITT (M'49)

(Burndy Engineering Company, New York, N. Y.)

Defining Frequency

To the Editor:

I would like to raise this important point in connection with my previous Letter to the Editor (*EE, Feb '51, p 180*): Is frequency correctly defined in current literature?

Too often I find present equations produce frequency in megacycles when I have every reason to expect cycles. The difficulty seems to be that the numerical values given to henrys and farads properly belong to abhenrys and abfarads whose orthodox conversion factors are 10^9 and 10^{-9}.

I would like to suggest that a more accurate definition of frequency in cycles, for both resonant and nonresonant circuits, would be

$$f=\frac{1}{2\pi}\sqrt{\frac{X_L}{X_C}\left(\frac{10^{18}}{LC}\right)}\text{ cycles}$$

IRVIN J. OSBORNE

(2550 San Clemente Avenue, Alhambra, Calif.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MISURE ELETTRICHE, Volume 2. Misure Elettriche di Laboratorio. By A. Barbagelata and P. Regoliosi. Libreria Editrice Politecnica, Cesare Tamburini, Milan, Italy, 1951. 370 pages, diagrams, charts, tables, 10 by 7 inches, paper, Lire 3,000. This second volume of a 2-volume set provides a comprehensive survey of the instruments and methods used in the laboratory measurement of electricity and electric circuits. Both the theoretical and constructional aspects are dealt with, with considerable attention to specialized cases. The first volume dealt with industrial instruments.

MODERN INTERFEROMETERS. By C. Candler. Hilger and Watts, Ltd., 98 St. Pancras Way, Camden Road, London, Northwest 1, England, 1951. 502 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, 57s.6d. (obtainable from Jarrell Ash Company, 165 Newbury Street, Boston, Mass., $9.75). This comprehensive treatise provides detailed description and the simple theory essential for the use of interferometers in astronomy, chemistry, engineering-nuclear physics and surveying. The material is organized according to the prospective use of each type of instrument. Diffraction gratings are covered in detail, and separate chapters deal with the Fabry-Perot etalon, Twyman interferometer, Michelson interferometer, Lummer-Gehrcke plate, Rayleigh refractometer, and Jamin interferometer.

NATIONAL ELECTRONICS CONFERENCE, Proceedings, Volume 6, Chicago, Ill., September 25, 26, 27, 1950. National Electronics Conference, Inc., 852 East 83rd Street, Chicago 19, Ill., 1951. 542 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.00. This Conference, like its predecessors, provided a forum for the discussion of electronic research, development, and practical applications. The book contains all of the papers, or digests thereof, presented at the 1950 Conference. Included in the numerous topics covered are microwaves and antennas, magnetic amplifiers, time-position measurement, circuits, tube technology, television, inspection and control, exploration and navigation, research instrumentation, computers, electroacoustics, oscillography, nucleonics, and signal generators and analyzers.

ORDNANCE PRODUCTION METHODS. Edited by C. O. Herb. Industrial Press, New York, N. Y., 1951. 534 pages, illustrations, diagrams, charts, tables, 11 by 8 inches, linen, $10.00. This collection of articles, which appeared in the magazine *Machinery*, during and after World War II, is devoted to preferred manufacturing methods for producing a variety of arms and ammunition. The articles are arranged in ten sections, according to the ordnance items dealt with. Among the topics covered are shells; cartridge cases and tanks; bombs, rockets and torpedoes; machine guns and small arms; artillery, anti-aircraft, and naval guns; gun mounts; and general ordnance manufacturing.

PLANT LAYOUT. By J. A. Shubin and H. Madeheim. Prentice-Hall, New York, N. Y., 1951. 433 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $7.35. Written for students of engineering and management, this book considers the principles, techniques, and procedures connected with the selection and layout of plant facilities. It discusses economic change and growth, the characteristics of industrial processes, plant location, product design, technological advance, and equipment replacement problems. Materials handling and building considerations are discussed in separate chapters.

LA PRATIQUE INDUSTRIELLE DES TRANSFORMATEURS. By M. Denis-Papin. Second edition revised. Editions Albin Michel, 22 Rue Huyghens, Paris, France, 1951. 197 pages, illustrations, diagrams, charts, tables, 10 by $6^1/_2$ inches, paper, 640 frs. Beginning with the fundamental theory and various types of transformers, this book continues with information on the construction and operation of transformers. Transformer cooling, special types of transformers, and methods of connection in 3-phase operation are dealt with, and data are provided for necessary calculations.

PRINCIPLES AND APPLICATIONS OF WAVEGUIDE TRANSMISSION. By G. C. Southworth. D. Van Nostrand Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 689 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $9.50. Addressed to students as well as to practical and theoretical workers, this book deals with the fundamental aspects of waveguide transmission. The early chapters provide an integrated account of principles, methods and applications of the mathematical theory of waveguide transmission, followed immediately by a physical interpretation of the phenomena most frequently observed. The remaining two-thirds of the text deals with current experimental research and practical applications.

PRODUCTION FORECASTING, PLANNING, AND CONTROL. By E. H. MacNiece. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 305 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $5.50. Of use to both students and executives, this book is devoted to basic principles. It explains how these principles are applied in many departments of industrial organizations. Some specific examples of effective applications are included. Balancing a consideration of the subject from an engineering viewpoint are treatments of economic and sonal implications. Problems and questions follow each chapter, and a bibliography is given.

RELAISBUCH. Edited by M. Walter. Fourth enlarged edition, Vereinigung Deutscher Elektrizitätswerke, Franckh'sche Verlagshandlung, Stuttgart, Germany, 1951. 308 pages, diagrams, charts, illustrations, tables, $9^1/_4$ by $6^1/_4$ inches, linen, 20 D.M. This book discusses relays used for protection against the damaging effects of short circuits on the individual parts of electric networks. Various types of relays and protective circuits are considered from the viewpoints of construction, efficiency, and application. Current and voltage transformers, generators, cables, electric rails, and motors are some of the individual components dealt with. The final section is devoted to the testing and maintenance of protective relays.

TABLES RELATING TO MATHIEU FUNCTIONS, prepared by the Computation Laboratory of the United States National Bureau of Standards; published by Columbia University Press, New York, N. Y., 1951. 278 pages, tables, $10^3/_4$ by 8 inches, cloth, $8.00. Continuing the series of specialized mathematical tables and computational helps, the present volume provides characteristic values, coefficients, and joining factors for Mathieu functions on which comparatively little has been published previously. The tables are carried out to from 7 to 9 decimal places. A brief treatment of the use of these functions and of the method of preparation of the tables is given in the introduction.

VACUUM-TUBE VOLTMETERS. By J. F. Rider. Second edition revised by J. F. Rider and A. W. Barber. John F. Rider, Publisher, Inc., 480 Canal Street, New York 13, N. Y., 1951. 422 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.50. This book deals with the principles of the various types of vacuum-tube voltmeters, their design, application, and repair. Every type of instrument is discussed, and most every commercial version is noted in detail, including a presentation of the schematic wiring diagram. The second edition reflects the extensive changes made in vacuum-tube voltmeters during the last ten years.

VECTOR REPRESENTATIONS OF DIFFERENTIAL EQUATIONS, THEIR SOLUTIONS AND THE DERIVATIVES THEREOF. By A. H. Boerdijk, Delft, Netherlands Bibliotheek der Technische Hoogeschool. Published by Waltman, Hippolytusbuurt 4–6, Delft, 1951. 177 pages, diagrams, $9^1/_2$ by $6^1/_4$ inches, paper, apply. In this thesis extensions of common vector diagrams related to a general linear equation are dealt with. In the case of nonhomogeneous differential equations the application of the diagrams is restricted to certain forcing functions. Application of the diagrams to various electrical and mechanical systems is demonstrated briefly.

DIE WISSENSCHAFTLICHEN GRUNDLAGEN DER ELEKTROTECHNIK. By H. Schönfeld. S. Hirzel Verlag, Leipzig, Germany, 1951. 258 pages, diagrams, charts, tables, $9^1/_2$ by $6^3/_4$ inches, stiff cardboard, 19 D.M. Written for the use of electrical engineering students, this book presents a broad discussion of basic principles. It considers the electrical characteristics of conductors and insulators, electromagnetic properties, and the effects of alternating and direct current on these characteristics and properties. Each chapter first considers principles and laws, then fundamental technical applications, and finally working procedures for the solution of electrotechnical problems.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Standards and Recommended Practices for Fabricating and Applying Laminated Thermosetting Decorative Sheets. Published by the National Electrical Manufacturers Association, the standards contained in this publication cover laminated thermosetting sheets intended for decorative purposes. Methods of testing for resistance to wear, boiling water, high temperature, cigarette burns, stains, and moisture are described, as well as the methods of test for color fastness of the surface to light and for dimensional change. $1.75 per copy. Available from the National Electrical Manufacturers Association, Publication Number *LP2-1951*, 155 East 44 Street, New York 17, N. Y.

Symposium on the Role of Non-Destructive Testing in the Economics of Production. Two general articles cover historical background, explanations of the various test methods, and generalizations on the types of structural irregularities that can be detected. Other additional articles deal with specific applications of various test methods. Illustrated. 164 pages. Available at $2.50 from: American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Proceedings, 1950 National Conference on Industrial Hydraulics. The 347-page volume contains the complete text of all technical papers presented at the sixth annual meeting. They deal with aeronautical, agricultural, civil engineering, chemical engineering, and refinery hydraulics; hose and fittings, control of surgers, hydraulic presses, and centrifugal pumps. Illustrated. Available from the Illinois Institute of Technology, Technology Center, Chicago 16, Ill., at $4.50 per copy.

A Regenerative Frequency Divider of Improved Stability. This report prepared by the Naval Research Laboratory covers final work on three ten-to-one regenerative dividers covering the frequency ranges of 100 to 10 kc, 10 to 1.0 kc, and 1.0 to 0.1 kc. The dividers are said to possess very stable operating characteristics for wide variations in plate voltage and input signal voltage, and exhibit desirable self-starting and non-critical tuning characteristics. Illustrated. 19 pages. Copies are available at 50 cents per copy from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

A Determination of the Acceptability of Magnesium Alloys as Enclosures for Portable Electrical Appliances. Underwriters' Laboratories, Inc., has evaluated the fire hazard involved in the use of magnesium alloys for portable electrical appliance enclosures. Limited ranges of performance were investigated utilizing carbon-to-magnesium and copper-to-magnesium arcs on both direct and alternating currents. Copies may be obtained from the Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago 11, Ill.

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TYPE 3

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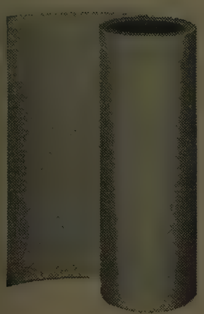


Silicone-treated Quinterra Type 3 is a high grade, Class H dielectric suitable for both interlayer and wire-wrapped insulation. It has outstanding moisture-resistance, high-temperature stability, and electrical characteristics—plus flexibility and adequate strength. Its unique combination of properties points the way to even greater compactness and even higher overload limits in many types of electrical devices . . . including air-cooled, inert gas and silicone-filled transformers.

High thermal-dielectric characteristics

Quinterra Type 3, like all treated Quinterras, is made from a completely inorganic base sheet of purified asbestos. The base sheet is of closed structure, has no holes, and has an inherent dielectric strength of at least 200 VPM. The silicone-treated base sheet maintains a dielectric strength of at least 350 VPM under continuous exposure to Class H maximum temperature of 180°C. The silicone treatment also provides high moisture resistance so the dielectric strength remains practically constant even under conditions of continuous high humidity.

*Quinterra is Johns-Manville's registered trade mark for its purified asbestos electrical insulation.

Excellent physical properties

Quinterra Type 3, is highly uniform in both texture and thickness—an important advantage in product design. Winding dimensions can be predicted accurately and much work can be eliminated in the final assembly. Quinterra is extremely flexible and very resistant to cracking or crazing. Actual use has proved that this insulation has sufficient mechanical strength for economical application in many electrical and electronic units.

Good laminating qualities

Like other Quinterra insulations, the new Type 3 may be successfully combined with other dielectric materials. It may be bonded to other inorganic materials such as mica or glass cloth.

Available forms

Quinterra Type 3 is supplied in sheets, rolls or tapes. Widths—¼" to 36"—can be cut to your specification. Available in various thicknesses from 3 to 9 mils.

If you have a problem you believe silicone treated Quinterra Type 3 might solve, you are invited to consult our staff engineers. We will gladly supply samples and additional information. Write Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville Electrical Insulations

INDUSTRIAL NOTES ....

IBM Licensed to Use English Cathode-Ray Tube Storage System in New Electronic Calculators. The cathode-ray tube storage system developed by Prof. F. C. Williams, English radar expert, is being introduced by International Business Machines Corporation (IBM) into its new electronic calculators. The company will use the Williams system under a licensing agreement with the National Research Development Corporation (NRDC) of London. The agreement gives IBM full use throughout the world of NRDC patents in the computing field, including many involved in the Manchester University digital computer.

In the cathode-ray storage system, information required in a calculation is stored in the form of dots and dashes on the face of the tube in a manner similar to the projection of a picture on the home television tube. The information is read back from the tube to the electronic computer in a few millionths of a second by passing the cathode-ray beam over the same area. As many as 2,048 items of information have been stored on a cathode-ray tube with a 24-square-inch screen.

President of Sylvania Honored. Don G. Mitchell, President of Sylvania Electric Products, Inc., was presented an honorary degree of Doctor of Laws by Northeastern University at its annual commencement exercises, for "initiative in introducing new products, in establishing far-sighted personnel policies, and in promoting decentralization in manufacturing." The company has also announced plans for construction of a new plant for the manufacture of welded lead-in wires for lamps, radio tubes, and other electronic devices at Nelsonville, Ohio.

United States Steel Appointment. Stephen P. Curtis, chief construction engineer, manufacturing division, United States Steel Company, has been assigned as project construction manager in charge of the Fairless Works facilities near Morrisville, Pa., of both the United States Steel Company and the National Tube Company, United States Steel Corporation subsidiaries.

Federal Telecommunication Laboratories Names Assistant Vice-President. William T. Rapp has been appointed an Assistant Vice-President of Federal Telecommunication Laboratories, Inc., research unit of the International Telephone and Telegraph Corporation.

Duro-Test Builds Electronic Research Laboratory. A new electronic research laboratory is being constructed for the Duro-Test Corporation at North Bergen, N. J. The laboratory will develop new products and carry on all company research.

Westinghouse Appointments. Dr. Clarence Zener has been named Associate Director of the Westinghouse Research Laboratories, Pittsburgh, Pa. Doctor Zener will serve also as acting manager of the Solid State Physics and Magnetics Department of the laboratories. The company has also named S. J. Merriman as assistant to the general manager of the East Pittsburgh divisions of the Westinghouse Electric Corporation.

New Company to Manufacture Mica From Domestic Sources. A new company, the Samica Corporation, has been formed in Delaware which will make high-grade mica electrical insulation from domestic scrap or small muscovite mica which has hitherto been unusable. Nearly all of the mica used today by the electrical and other industries in this country is imported from India and Madagascar and is processed by hand labor. The Samica Corporation will use a French process, patented in this country, which is based on experiments by the late Jacques Bardet in 1939 and first used on a laboratory scale in 1943, in co-operation with the French company, Prosilis, S. A., of Paris. Since that time a factory has been erected at Valdoie, France, where the process is being used for commercial production. Participants in Samica Corporation are Prosilis, S. A., Paris, France, the Swiss Insulating Works, Breitenbach, Switzerland, and the Mica Insulator Company, Schenectady, N. Y.

Quaker Rubber Corporation Expands. The Quaker Rubber Corporation, Division of H. K. Porter Company, Inc., has begun a quarter-million-dollar expansion of its hose manufacturing facilities to produce high-pressure wire-braided hose for the United States Air Force. The entire sum will be spent for special manufacturing equipment necessary for production.

Lear Elects Vice-President. W. D. Espy has been elected a Vice-President of Lear, Inc. Other newly elected officers include A. Durham, assistant secretary and assistant treasurer, and George K. Otis, assistant secretary. The Board of Directors re-elected Richard M. Mock, President; Paul Moore, Executive Vice-President; A. G. Handschumacher, Vice-President; A. F. Haiduck, Vice-President; T. M. Belsbe, Vice-President, and J. A. Golde, Secretary.

G-E News. The General Electric Company will start construction of the first buildings in its proposed Appliance Park as soon as it takes title to a 700-acre tract in Buechel, Ky. Ultimately, the multi-million-dollar park will be the manufacturing, engineering, marketing, and administrative headquarters for all General Electric's major appliance operations.

The General Electric Company also has announced the following: Harry L. Erlicher, Vice-President of the company, has been named special assistant to Under-Secretary of the Army Archibald S.

(*Continued on page 24A*)

It's a fact that

✓ Production of AlSiMag Technical Ceramics during 1951 has been greatly increased by:

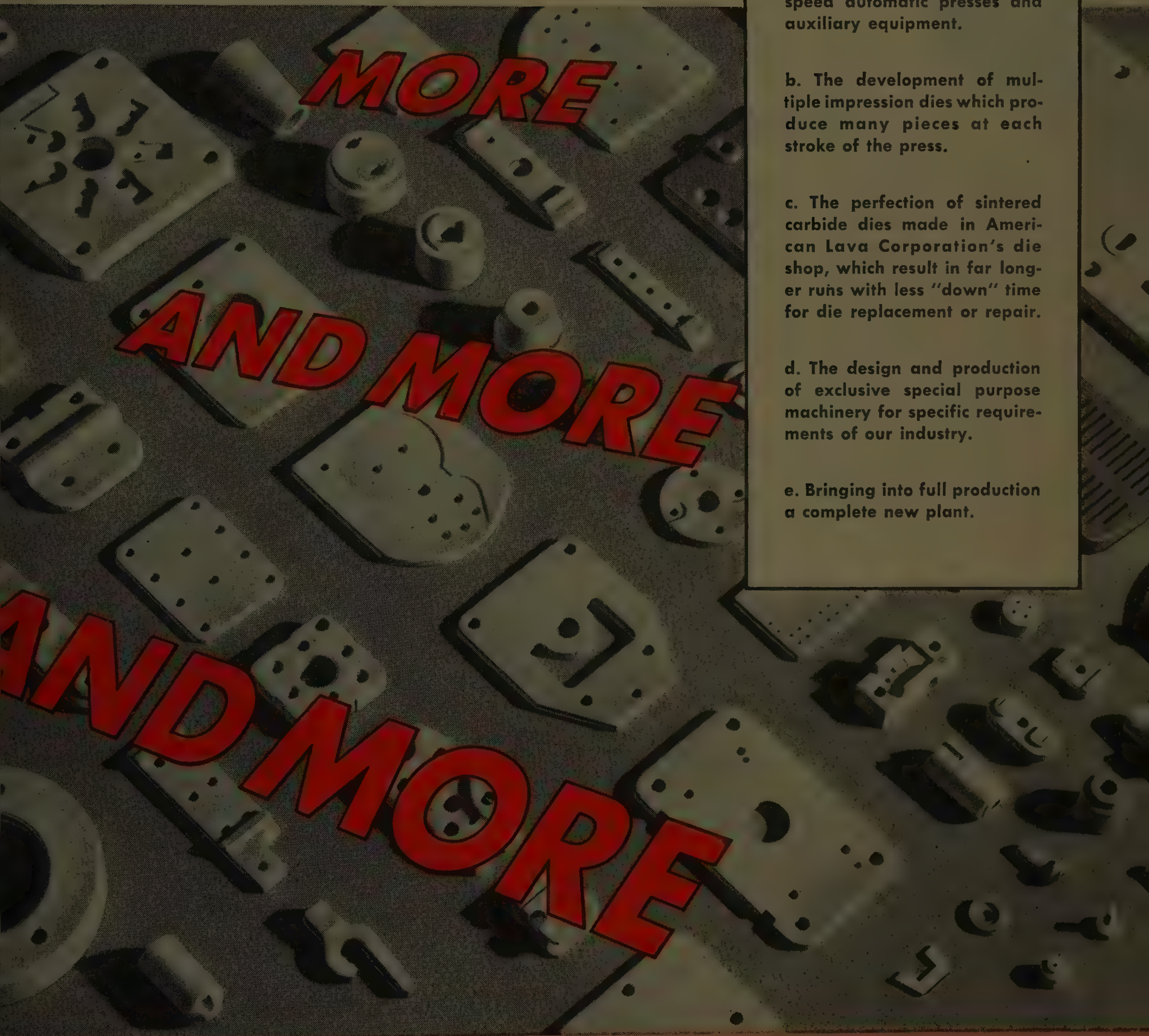
a. Installation of new rotary presses and new large high speed automatic presses and auxiliary equipment.

b. The development of multiple impression dies which produce many pieces at each stroke of the press.

c. The perfection of sintered carbide dies made in American Lava Corporation's die shop, which result in far longer runs with less "down" time for die replacement or repair.

d. The design and production of exclusive special purpose machinery for specific requirements of our industry.

e. Bringing into full production a complete new plant.



Large as our 1951 production gains have been, they have not enabled us to keep pace with the unprecedented demand for AlSiMag Custom Made Technical Ceramics. But if you will be patient with us just a little longer we should soon be able to meet almost any requirements and any reasonable delivery date. Complete new plants and production facilities should be available near the time you read this advertisement. • This has been planned so carefully and training programs have been under way so long that we feel confident the increased production will be fully up to our highest standards and maintain our reputation for delivery on specification and at the promised time.

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(*Continued from page 16A*)

Alexander; A. T. Chandonnet has been named manager, Lynn (Mass.) turbine division; Clayton S. Coggeshall has been appointed assistant to the manager and Robert S. Neblett has been named manager of sales, turbine divisions; William V. O'Brien, a commercial Vice-President of the company, has been made manager of the firm's apparatus marketing division; and William A. Sredenschek has been appointed manager of materials and purchasing.

Hytron Radio Becomes a Division of CBS. The Hytron Radio and Electronics Company is now a division of the Columbia Broadcasting System, Inc. Management and general policies will remain the same. Hytron is building a new, ultramodern plant for manufacturing receiving tubes at Danvers, Mass., which will double the firm's facilities for receiving tube production.

Allis-Chalmers Appointment. F. T. Sagemiller has been named assistant to William C. Krecklow, production control manager of the Allis-Chalmers Manufacturing Company's general machinery division. Mr. Sagemiller succeeds F. C. Butler.

Sylvania Appointments. P. M. Pritchard has been made general sales manager, parts division, and Karel van Gessel has been appointed co-ordinator of foreign manufacturing affiliates of Sylvania Electric Products, Inc.

Nichols Named Manager of Raytheon Research. Nathaniel B. Nichols has been named manager of the research division of the Raytheon Manufacturing Company.

NEW PRODUCTS • •

Air Filter. An absolute air filter, originally developed for the Atomic Energy Commission and capable of removing better than 99.98 per cent of all dust, smoke, fumes, radioactive particles, spores, and other microscopic foreign matter from the air, is now being produced in commercial quantities by Cambridge Corporation, 350 South Geddes Street, Syracuse, N. Y. Manufactured in two standard sizes with rated capacities of 500 and 850 cubic feet of air per minute, the filters are especially useful wherever absolutely clean air is needed for processing, or where toxic or radioactive fumes must be prevented from escaping into the atmosphere or from entering work areas. The filtering material is a soft, felt-like paper made of especially treated pulp containing fine asbestos fibers. The paper is folded into accordion pleats and packed into a 24- by 24-inch frame. The 500-cubic-foot-per-minute size is $5^7/_8$ inches deep, and the larger size is $11^1/_2$ inches deep. Inquiries may be directed to the Cambridge Corporation.

(*Continued on page 28A*)

(*Continued from page 24A*)

Analogue Digital Converter. This device converts variable mechanical positions into unambiguous electric contact settings. Each unit has a number of decades, which may be added or deleted at will, and each decade has ten possible positions. When a rotary motion is applied to the shaft of the converter, the output is in the form of discrete electric contact positions suitable for operating electric typewriters, for feeding information to digital computers, or for specific visual display The traversing speed is at present limited to about 250 number changes per second in either direction or 2,500 changes per second with a special adapter. This limitation is a conservative safeguard against brush wear; and excessive speed itself does not produce error because the device is not dependent on counting or accumulating pulses. Genisco Incorporated, 2233 Federal Avenue, Los Angeles 64, Calif., manufactures the converter and will supply information on request.

Coil Form Kit. Three each of five different ceramic coil forms are contained in this kit which is intended to provide design engineers and experimenters with coil forms for use in the development of prototypes or pilot models. Each form in each group is provided with a different powdered iron slug (high, medium, and low frequency); and extra slugs of silver-plated brass are provided for each form as alternates to the iron slugs. The form diameters vary from 3/16 to 1/2 inch and over-all mounted heights vary from 19/32 to $1^{11}/_{16}$ inch. They are made of grade *L-5* silicone impregnated ceramic which meets *JAN-1-10* specifications and all necessary hardware is furnished electroplated and nonferrous to meet military requirements. Also provided is a hand chart which identifies slug types by color code and part number, and states approximate frequency ranges and permeabilities. The Cambridge Thermionic Corporation, 460 Concord Avenue, Cambridge 38, Mass., will receive inquiries about these kits.

Winding Temperature Equipment. The General Electric Company announces a new line of temperature indicating devices for power transformers. The line consists of a hotspot indicator-relay, a hotspot indicator for local indication, and a hotspot indicator for remote indication. The indicator-relay (type *AWR*) provides in one unit an accurate indication of hotspot temperature as well as automatic starting of cooling fans, oil pumps, alarms, or any other circuit at a predetermined hotspot temperature. The device consists of a thermometer, three microswitches, and a heat-sensitive element enclosed in a hermetically sealed instrument case. A projection from the main instrument case containing the heat-sensitive element is inserted into a liquid-tight well on a transformer. The transformer is equipped with a current transformer the secondary current of which is circulated through a heating coil fitted around the liquid-tight

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well. The combination of liquid temperature and the temperature which is a function of the current flowing through the winding gives a simulated hotspot temperature. The hotspot indicator for local indication (type *AW*) is similar to the type *AWR* unit except that the former has only one alarm contact. For remote indication the type *AW-400* detector coil is furnished. Interrogations may be extended to the Transformer and Allied Product Divisions of the General Electric Company, Pittsfield, Mass.

Dry-Type Transformers. A new line of dry-type transformers featuring class *B* insulation is announced by General Electric's specialty transformer and ballast divisions. For single-phase 60-cycle operation the new design provides smaller transformers with an average weight reduction of 30 per cent throughout the line, and some models weigh less than half as much as the units they replace. Improved core steels and increased amounts of inorganic insulating materials make possible these size and weight savings. The line will ultimately consist of about 50 models in ratings of 3 kva and upwards. It will include transformers equipped with two 5-per cent rated kilovolt-ampere taps below rated primary voltage, transformers for 32-volt applications, transformers for general light and power service, and autotransformers for general light and power service. Further information is available from the General Electric Company, Schenectady 5, N. Y.

Industrial Engraving Machine. Model *I-S* portable industrial engraving machine is announced by New Hermes, Incorporated, 13–19 University Place, New York 3, N. Y. The machine enables unskilled labor to engrave small name plates as well as large panels up to 25 inches wide by any length. It is equipped with a multiratio tracing arm for engraving 15 different sizes lettering from 3/64 to 1 inch. Full information may be obtained from the manufacturer.

Beta-Ray Gauge. Utilization of nuclear reactor by-products now makes possible an accurate and continuous production line inspection of 100 per cent of the output of mills manufacturing such materials as steel, aluminum, brass, rubber, plastics, paper, and coated textiles. Announced by Industrial Nucleonics Corporation, 1205 Chesapeake Avenue, Columbus 12, Ohio, the gauge measures instantaneously the weight per unit area or thickness of sheet material directly on the production line. No contact is made with the material being measured, the measurement is continuous, and no recalibration or checking with standard samples is necessary once calibration is made. Accuracy is high—variations of a few microinches can be measured in steel—and the reading is not affected by variations in moisture, color, composition, and so forth. Compensation is automatic for temperature changes, dirt accumulation, and other factors which contribute to inaccuracies. The gauge consists of a source-detector unit and a

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console. The source-detector unit is a U-shaped mount on which is secured an ionization chamber radiation detector and a source box containing the beta ray emitting radioisotope strontium 90. The material under test passes between the source box and the detector. The console contains electronic circuits, power supplies, recording equipment, and operating controls. Detailed information may be obtained from the manufacturer.

Metal Detection Equipment. The Guardsman series of metal detection equipment, announced by the Radio Corporation of America (RCA) engineering products department, will indicate the presence of minute particles of metals or alloys, whether magnetic or nonmagnetic, which contaminate nonmetallic products. The products may pass through an inspection aperture or on an endless conveyor belt at rates of 10 feet to 1,000 feet per minute. The detector consists of two units. The control unit, which is the same for all models and applications, is $8^1/_4$ inches high, $6^3/_4$ inches wide, and 10 inches deep. It weighs 20 pounds. The second unit is the inspection head and it is available in four different styles to meet the special requirements of the installation. Two have rectangular heads and are designed for inspecting candy, pharmaceuticals, and other products that can be carried on a conveyor belt; the other two have round apertures for inspecting cigarettes, liquids in glass tubes, and similar items that can pass through a tube or trough. The materials are screened by a high-frequency electromagnetic field generated by an electronic oscillator. The reaction caused by the presence of metal particles operates a relay which in turn may be used to operate an alarm, marking device, or ejecting mechanism. Domestic and Canadian marketers of the equipment will be the Eriez Manufacturing Company of Erie, Penna., and RCA International will handle foreign export.

TRADE LITERATURE

Single-Phase Inductrols. The General Electric Company, Schenectady 5, New York, has published a new bulletin, *GEC0795*, on single-phase inductrols (low-voltage, dry-type induction voltage regulators), which is available upon request.

Tube Manual. A revised edition of the Sylvania Technical Manual in loose-leaf format has been issued. The manual contains an 84-page engineering data section, which describes more than 500 receiving tube types, television picture tubes, and information on vacuum-tube operation. Priced at $2.00 per copy, the manual may be obtained from Sylvania Electric Products, Inc., Emporium, Pa.

Circuit Breaker Panelboards. A new booklet, *B-5260*, describing circuit-breaker

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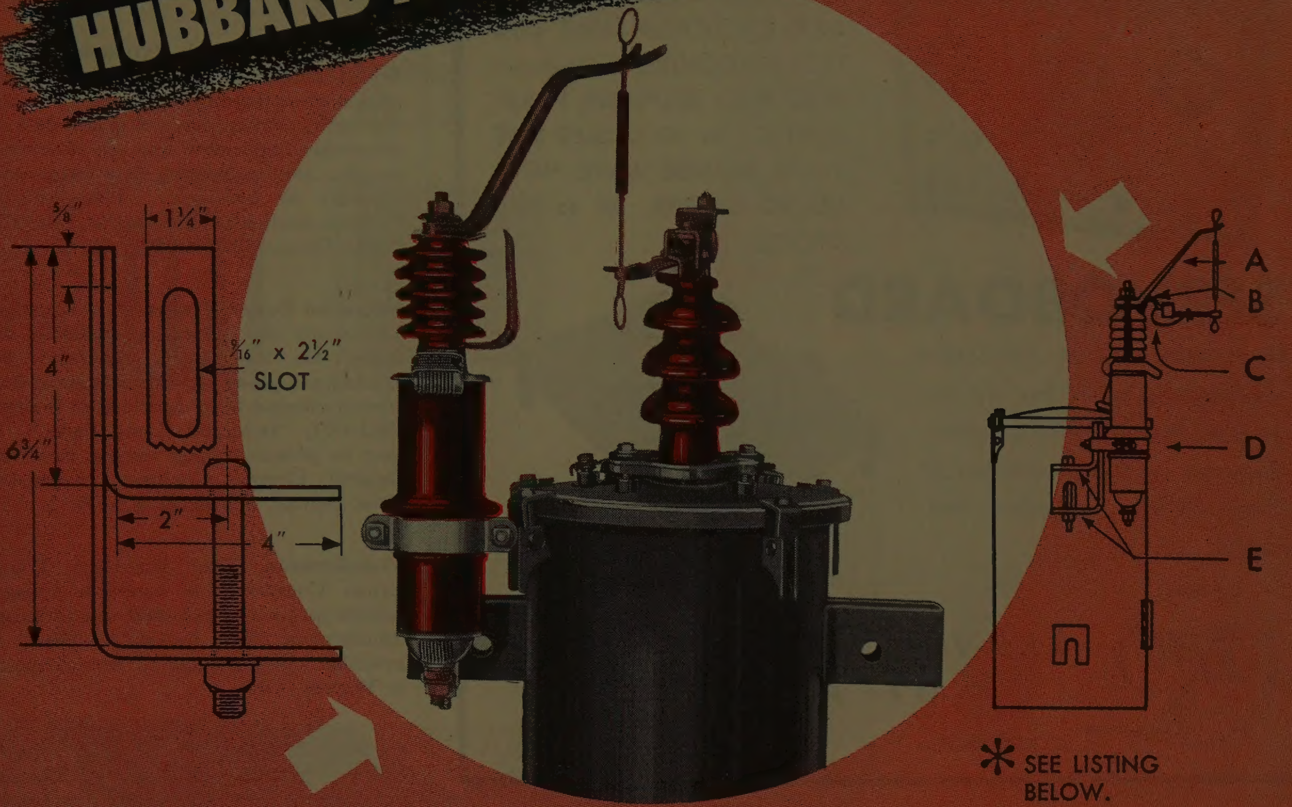
HUBBARD AUTOGAP FUSE KITS



GIVE—COMPLETE PROTECTION

Hubbard Autogap Fuse Kits provide transformer protection with external accessibility. All parts are easily inspected. The fuse link is exposed, making it easy to select the right fuse for proper coordination. Transformer and kit can be assembled on the ground and mounted as a single unit. Kits for Vertical and Horizontal Autogaps are also available for factory assembly.

*

- A *Bronze Fuse Fork*
- B *Terminal Lug Adapter*
- C *Chrome Steel Spring Assembly*
- D *No. 2332-9kv Autogap Arrester*
- E *Heavy Duty Adjustable Mounting Bracket No. 2349*

HUBBARD AND COMPANY

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"Hang the Load on Hubbard Hardware!"

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panelboards for the control and protection of lighting, appliances, and other power applications is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Thermocouples and Pyrometers. The Bristol Company has issued a new 56-page edition of its thermocouple and pyrometer accessories catalog, containing new data on the proper application and use of thermocouples, and engineering data on modern practices in pyrometry. This bulletin, *P1238*, is available upon request from The Bristol Company, Waterbury 20, Conn.

Industrial Power Packs. A new midget load center unit substation especially designed for low-voltage, regulated a-c lighting and power services in factories and laboratories has been described in bulletin *GEA-5571*, "Inductrol Power Packs." It may be obtained upon request from the General Electric Company, Apparatus News Bureau, Schenectady 5, N. Y.

Transformers. The Standard Transformer Company has issued a 32-page bulletin on current, potential, and metering transformers. The bulletin, *S-501-B*, is available upon request to the company at Warren, Ohio.

Carbon Brushes. A 28-page booklet entitled "Carbon Brushes for Electric Equipment" has been made available by the General Electric Company, Schenectady 5, N. Y. Designated publication *GEA-5597*, the booklet describes the fundamental considerations given to the design, application, and manufacture of carbon brushes and includes a section on brush terminology.

Electronic Components. Catalogue *RC8*, issued by the Stackpole Carbon Company, St. Marys, Pa., describes fixed and variable resistors, iron cores, line and slide switches, choke forms and capacitor units, and ceramag cores. It may be obtained upon request to the company.

Stabiline Automatic Voltage Regulators. The Superior Electric Company has released a bulletin, *S 351*, featuring the complete line of standard Stabiline automatic voltage regulators. It is available from the company at Bristol, Conn.

Teletrons. A new Du Mont Teletron catalogue containing technical information on the latest types of Teletron picture tubes may be obtained from the Cathode-Ray Tube Division, Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Avenue, Clifton, N. J.

Power Factor Visualizer. A power factor visualizer (chart *SA-6739*) which presents an explanation of the use of capacitors in solving low power factor problems is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.